CROSS TALK

▶**ECHOES . . .** Something new has been added to the repertoire of tricks used by electronic engineers. This is the echo technique. Shoot a radio wave into the air and it will be reflected by any conducting surface, sending back to the transmitter echoes of the original signal. A partially ionized layer of gas, an airplane or a ship at sea will do it. Since the directivity at the transmitter may be very great, the location of the reflector in elevation and azimuth can be determined.

Furthermore, since radio waves travel at a finite velocity (186,000 miles per second or about 327 yards per microsecond) the distance of the reflector can be determined.

Sound waves travel through sea water at a finite rate—about 5000 feet per second—and since a fairly narrow beam of sound waves can be produced in the supersonic region, nature and electronics have provided us with a pretty good submarine detector. It is also good for sunken ships, reefs or a school of fish, all of which will produce echoes. Sound waves travel through the earth with known characteristics as the seismologists and the geophysicists have discovered and utilized.

Now comes Professor Firestone of the University of Michigan. He holds a vibrating piezoelectric plate up against a block of metal. Sound waves in the supersonic region travel through the plate and return to the front surface as echoes produced by the rear surface, or by flaws within the block. So, electronics has provided industrial engineers with a new, sensitive, nondestructive test, a method of measuring the thickness of a metal plate whose rear surface may be inaccessible, or for exploring the interior for hidden flaws.

The wonder is that all of this wasn't done long ago!

▶**SYMBOLS . . .** Some time ago, October issue to be explicit, ELECTRONICS offered a free lunch to the author of the first paper to arrive here for publication using the compromise symbols for electronic components adopted by the American Standards Association. Dr. Harrison's paper on Klystron oscillators won the free lunch, and a very pleasant time was had by all.

The symbols problem is serious. For years there were two sets of symbols for certain widely-used components and great was the confusion compounded thereby. Now that there has been agreement, it behooves everyone —engineers, students, professors, authors, publishers—to stick together and to wipe out and forget the old confusion.

As a matter of cold hard fact, too much of our time and effort is spent fixing up the diagrams of authors who are still acting as if no standardization had ever been accomplished. This indecent use of time and energy must be better employed.

The correct symbols to use can be ascertained by looking at ASA Bulletin Z32.5-1944.

▶**FREQUENCIES . . .** On January 16 the FCC announced new allocations for services operating above 25 Mc. Frequencies assigned various communications and industrial services are listed in the "News of the Industry" department pages of this issue. Next month ELECTRONICS will present a detailed analysis and interpretation of what the allocations mean to the future of the industry.

▶**BJ . . .** In spite of the fact that many knew that B. J. Thompson, outstanding electronic engineer, had been missing after a Mediterranean flight, the final announcement of his death was a distinct shock. On a special mission for the Secretary of War, Mr. Thompson's plane disappeared on the night of July 4, last year.

"BJ", as Mr. Thompson was affectionately known by a very large number of radio and electronic engineers, was one of the most promising young men in our field. His contributions already made were of the first rank; the development of the acorn type tubes being best known. In addition, the high esteem in which he was held by his associates and the men who worked under him and his fellow engineers throughout the industry makes his loss very great.

Planning an F-M Station

A practical discussion of the problems confronting a-m stations contemplating the new service. Notes on the selection of sites, estimation of coverage, determination of required transmitter power, choice of antennas, and building layouts

By P. B. LAESER
FM-Television Engineering Supervisor
WMFM-WTMJ
The Milwaukee Journal Radio Stations
Milwaukee, Wisc.

AFTER THE DECISION is made to enter the f-m field, the broadcast station engineer is confronted with the job of satisfying management as to the cost of serving the proposed market area. Can he use any of his present a-m facilities? What are the possible sites for the transmitter and antenna? Are suitable wire lines available or does he have to resort to a studio-to-transmitter (STL) link?

Basically, the problem settles down to taking inventory of the present transmitter site, determining whether a signal can be propagated from there over the territory specified, and deciding what will be necessary to feed a high-quality program service from the studio to the transmitter.

Determination of Coverage Area

In the majority of cases an entirely new transmitter location will be chosen for the f-m installation because good locations for broadcast band antenna systems are not often satisfactory for f-m.

Many a-m stations are located in lowland or swamp areas to provide a ground system with good conductivity. This particular consideration is not an important factor in the f-m band. More important is the elevation of the terrain with reference to the area to be served, and a site overlooking as much area as possible is needed.

Signal propagation over the broadcast band shows a wide variation between extreme frequencies for a given power and antenna system. This is in direct contrast to the f-m band, where substantially the same results are had on any frequency within the band. Very-high-frequency signal propagation results in coverage more definitely related to specific areas than standard broadcasting. Recognizing this, the FCC is authorizing applicants to apply for specific trading areas and has set up the following four classifications of coverage:

Class A. An area comprising a limited trade area and a city, usually composed of one small city and adjacent area.

Class B. An area comprising a basic trade area and a principal city, usually composed of a principal city, one or more smaller cities and the areas adjacent to these cities.

Class C. An area of at least 15,000 square miles, comprising primarily a large rural area and that part of basic trade areas which cannot be served by stations assigned basic trade areas due to economic and technical limitations.

Class D. An area having substantially different characteristics (social, cultural and economic) from those specified in classifications A, B and C, where the establishment of a special program and technical service is in the public interest.

Five channels are at present set up for non-commercial educational stations. Since a request for other frequencies and additional channels has been made by the RTPB, the present allocations for the various

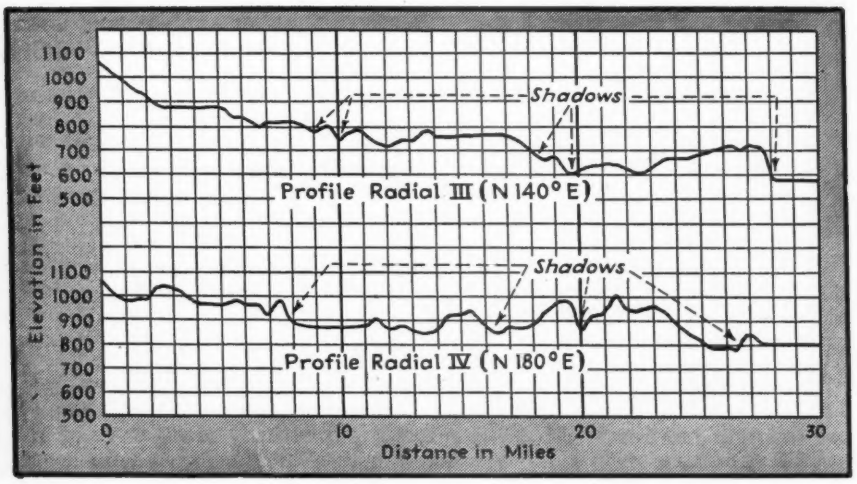
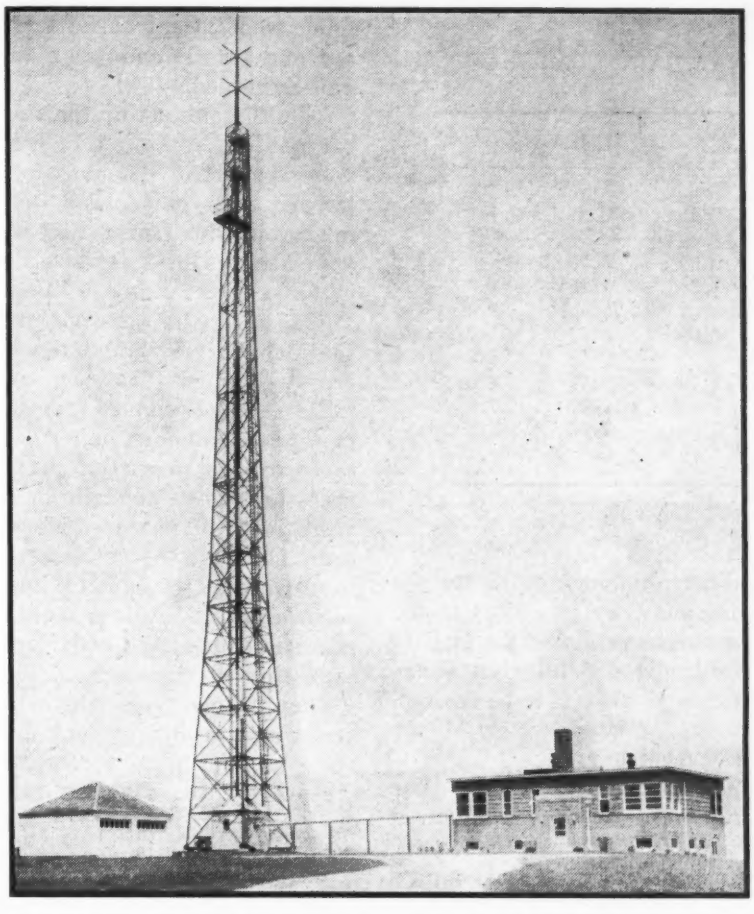


FIG. 1—Profile of the land elevation above sea-level along each of two radials centered on Richfield, Wisc. Note that a number of points, even within the primary service area, are in shadow



WMFM transmitter building and antenna at Richfield, Wisc. The tower is 200 ft high, and on top of it is a two-bay turnstile. The platform at the 175-ft level supports a studio-to-station link receiving antenna. The elevated trough carrying two coaxial transmission lines between transmitter house and tower may be seen

classifications may be modified in the near future.[1]

Complete data on trade areas can be obtained by referring to available maps.[2]

Transmitter Sites and Shadow Effect

Many cities have unusually tall buildings which are well suited for f-m installations. However, the location of such buildings in relation to the service area should be considered, especially if a circular pattern is contemplated. As an illustration, cities on the seaboards and on the Great Lakes in some instances are adjacent to large water areas.

If the initial outlay is for a class A station and plans are not for a large rural coverage, the transmitter should be placed at a point where the noise level is highest and population most dense. At the outskirts of the area, probably, the population will be sparse and noise levels low. Lower signal intensities will therefore be tolerable. Adequate lines between the studio and transmitter generally are available for a 50 to 15,000-cps circuit when the transmitter is located in a city.

There will be installation difficulties but these are not insurmountable. For example, it may be necessary to hoist material outside a building in a busy area or dismantle large units to fit the elevators. Steel beams may have to be cut in two, transported to the roof and welded together again. Such work is generally best carried out on a Sunday, roping off the street below to minimize danger to the populace. In negotiating for building space, the lease should clearly specify the extent of the roof rights for the antenna system.

To cover a large metropolitan area and large rural areas or large rural areas plus several metropolitan areas (class B or C) it is necessary in most cases to locate the transmitter at a point quite remote from the studio. Fortunate is the station that is located on high ground overlooking its principal city and trade areas. In choosing this site several factors must be considered, elevation being the prime requisite.

Obstructions such as hills, cliffs,

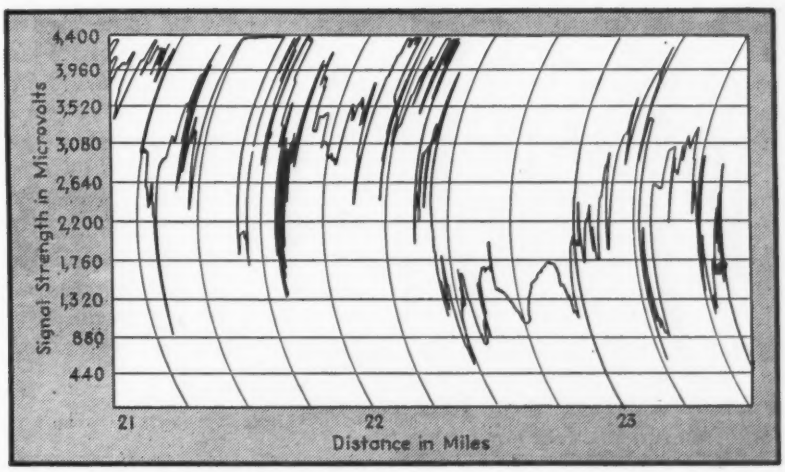


FIG. 2—Shadows such as those shown in Fig. 1 produce marked variations in signal strength, as shown on this graph obtained by continuous recording while driving through a hilly area

TABLE 1—MULTI-ELEMENT ANTENNA GAIN, COMPARED WITH DIPOLE

	TURNSTILE			CIRCULAR		
Layers	Field Gain	Power Gain	D*	Field Gain	Power Gain	D*
1	0.707	0.50	0.0	0.89	0.79	0.0
2	1.12	1.25	0.5	1.28	1.66	1.0
3	1.41	2.00	1.0	....	....	2.0
4	1.66	2.75	1.5	1.86	3.47	3.0
5	1.87	3.50	2.0	....	....	4.0
6	2.06	4.24	2.5	2.45	5.25	5.0
7	2.26	5.05	3.0	....	....	6.0
8	2.40	5.76	3.5	2.66	7.08	7.0
10	2.69	7.24	4.5	....	....	...

* Distance in wavelengths between top and bottom elements.

or buildings, when present in the transmission path, introduce attenuation and these zones are known as shadow zones. The area encompassed in a shadow will receive only a fraction of the signal intensity available at other equidistant points, the actual signal strength depending on the degree of shielding. Examination of the elevation along sample radials shown in Fig. 1 will reveal cases where line-of-sight transmission is not obtained. It is not unusual to find shadows such as these in the primary area of existing f-m stations. Figure 2 shows a sample recording of signal strength made while driving through such a shadow.

If the station is planned for the northern states or mountainous country, a location on a main highway or at least a good secondary road maintained in the winter is advantageous, making it possible for the operating personnel to gain access to the property on an all-year-round basis. A hill reached by a good highway has an advantage over one of somewhat higher elevation but inaccessible, because the cost of additional tower height sometimes is less than laying out a new road. Also, by staying close to highways, advantage can often be taken of power facilities which interconnect cities. Dual power service from separate feeders is desirable. Too great a distance from power lines may require the installation of an independent emergency generating plant. Furthermore, complete dependence on local power facilities may not be advisable in all cases.

Another qualifying factor in choosing between two sites is the nature and elevation of the land in their immediate vicinity. A sharp drop-off on all sides is to be desired, especially in the direction of the major market area.

A considerable amount of time and effort can sometimes be saved by procuring quadrangle maps for the various sections of the country under scrutiny. Immediately it will become apparent which of several likely spots has greater elevation above sea level and sites can be evaluated accordingly. If there is any doubt, an altimeter should be obtained and checks made to verify.

Telephone service may be obtained in some locations not too far from inter-city trunk systems by branching off with underground circuits. In one instance a line was laid underground for four miles after easements from property owners had been obtained. Lines in cables are preferred to open-wire circuits because of the latter's susceptibility to atmospheric noises. Where telephone service is not practical a station-to-transmitter-link must be installed.

The possibility of a water system should not be overlooked, especially if a high-powered transmitter is planned which necessitates auxiliary cooling of the air plasts and a constant supply of water for the evaporator.

Signal-Strength Contours

After the most suitable site has been chosen and all the factors related to the site are set down and evaluated, the next step is to determine what size transmitter, what antenna height and what antenna gain is needed.

The FCC has set up the standard for good reception as 1000 microvolts for urban listeners in areas having high noise levels and 50 microvolts for rural listeners in area having low noise levels. It is possible, by referring to FCC Chart 41722,[3] to predict at what distance the 1000-microvolt and the 50-microvolt points occur on various radials with assumed transmitter powers and antenna heights. Since these are only predictions, it will be necessary after the station is in operation to procure measuring equipment or engineering service to prove that the contour lines are as calculated. Adjustments compensating for either under or over-estimates can then be made.

Surveys made on v-h-f stations sometimes show great discrepancies in the pattern compared to the predictions. This, no doubt, is due to irregularities in the terrain involved. Mountainous country and large cities show great deviations compared to the surveys made in country more level and less densly populated. Figure 3 is an illustration of the predicted contours of WMFM, Milwaukee (formerly W55M).

After establishing the two contours, the area in square miles can

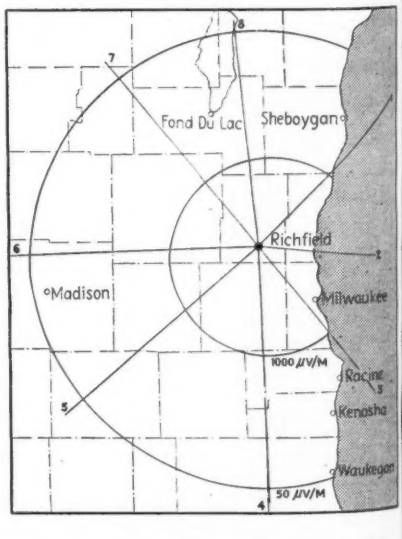


FIG. 3—Map showing predicted 1000 and 50-microvolt contours around WMFM. Radials on which signal-strength measurements were later taken are numbered

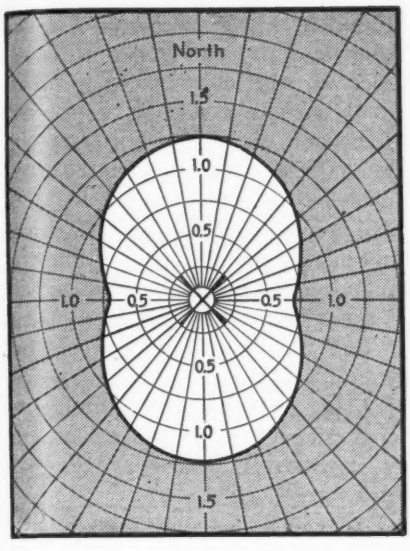


FIG. 4—(Left) Radiation pattern of a 60-deg phased turnstile called a "dumbell", having equal currents in all elements, showing north-south directional gain over a 90-deg turnstile

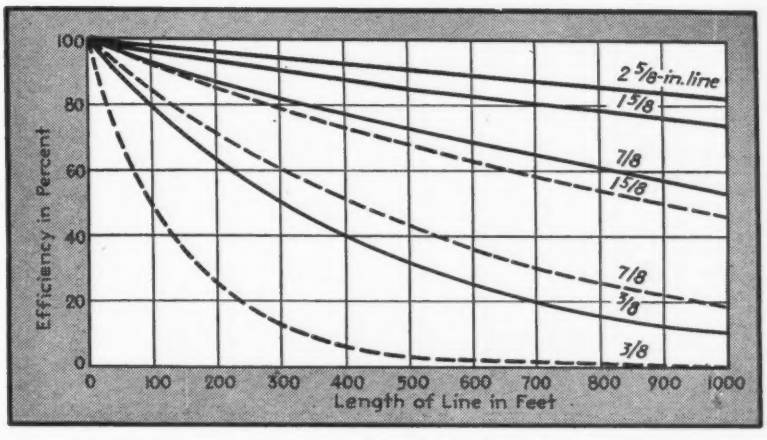


FIG. 5—Graph illustrating the percent efficiency of various sizes of coaxial transmission line using Isolantite insulation. Solid lines show efficiency at 50 Mc. Dashed lines show efficiency at 300 Mc (General Electric)

be measured by the use of a planimeter. Population analysis of the service area can then be carried out.

In the majority of cases it is probable that the f-m transmitting antenna will be independent of other antennas and on its own supporting structure. However, a question arises and will come up again and again in the future regarding the possibility of mounting an f-m antenna on the tower of an active a-m station. Where this is contemplated each tower will present its own structural problems and these will have to be analyzed by the manufacturer. The effect of loading the a-m tower with a heavy f-m array will, particularly, have to be carefully calculated. There is also the possibility that adding an f-m radiating structure might change the a-m antenna current distribution, and the phase angle in the case of a directional array.

Antennas

Horizontal polarization of the f-m antenna is recommended because of the high power-gain attainable while maintaining a structure rugged enough to combat the elements. Vertically-polarized antennas giving high power-gain are comparatively difficult to construct, whereas stacked horizontal units giving appreciable gain are readily obtained.

There are several ways of accomplishing antenna power-gain, namely, by stacked circular antennas commonly known as "donuts", by "turnstiles" using successive layers of arms radiating from the mast, or by square loops stacked one above the other and known as Alford loops. There are also several other suggested methods of securing horizontal directivity, such as corner reflectors and spiral antennas. Such antennas effectively increase the power by reducing the signal radiated vertically and concentrating it in the horizontal plane, i.e., along the earth's surface.

The effective signal radiated (ESR) is the all-important factor in evaluating an f-m system and, therefore, it should be determined whether a high-gain antenna system and a low-powered transmitter or a low-gain antenna and a high-powered transmitter are to be used. For example, for one typical transmitter site a calculated 4000 watts of effective signal is needed to assure a 1000-microvolt contour at 20 miles. This can be accomplished with 4000 watts of generated power using an antenna with a power gain of 1, or by using a more complex antenna system giving a gain of 4 and reducing the generated power to 1000 watts. The results in either case are theoretically identical. By referring to the following table of more or less standardized transmitter sizes it will be noted that 4000 watts falls between 3 and 10,000 watts, making it necessary to install a 10-kw transmitter.

250 watts
1,000 watts
3,000 watts
10,000 watts
25,000 watts
50,000 watts
100,000 watts

It is obvious that the most economical approach in this case would be to use a 1-kw transmitter with an antenna having a gain of 4 since the cost of the antenna would not approach the cost of a 10-kw transmitter. In addition, the maintenance and upkeep would be very much in favor of the smaller transmitter and the more complex antenna system.

Table I gives a comparison between two popular high-gain antenna types and a dipole having a gain of one. Comparative values of antenna gain for equal mast height are in favor of the turnstile, as the

TABLE 2—TURNSTILES VS DIPOLE

90-DEGREE		60-DEGREE	
		Field Gain	
Layers	Field Gain	North-South	East-West
2	1.12	1.36	0.79
4	1.66	2.02	1.19
6	2.06	2.51	1.44
8	2.40	2.93	1.68

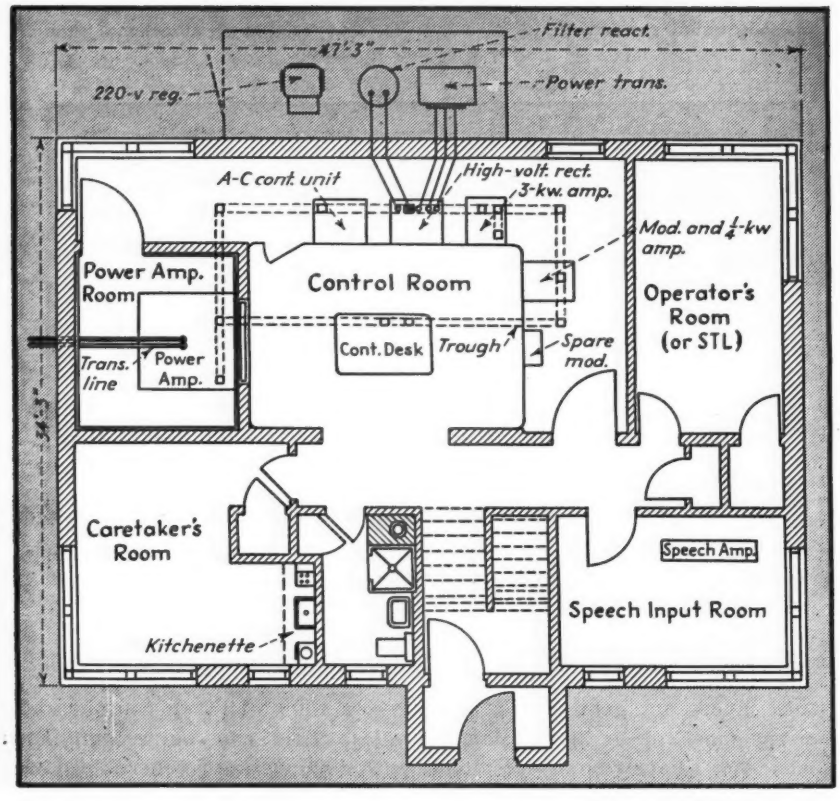


FIG. 6—First-floor plan of the WMFM transmitter building at Richfield, Wisc.

distance between layers of the turnstile antenna is ½ wavelength and of the circular antenna one wavelength. This corresponds to approximately 10 and 20 feet respectively, depending on the exact frequency used. In the event of CAA restrictions on height of the tower structure this represents an important factor.

Some modification of pattern can be obtained with a turnstile by either phasing or varying the current relationship of the elements in quadrature to obtain an elliptical pattern if it is desired to cover an elongated market area. Using a 60-deg phased turnstile, with equal currents, an increase of about 22 percent in one direction can be obtained with a loss of approximately 30 percent in the other direction. Figure 4 shows the pattern of a 60-deg turnstile that has been dubbed the "dumbbell." Table II shows the relative increase in field gain over a 90-deg turnstile for various numbers of layers. Note that the desired north-south field gain of a four-layer turnstile 60-deg phased is 2.02 compared to a standard 90-deg turnstile of six layers giving a gain of 2.06. Thus the 60-deg turnstile will provide a solution to some of the cases where an irregular trade area cannot be served adequately with a circular pattern.

Transmission Lines

Considerable trouble has been experienced in the past with transmission lines. Open-wire and coaxial lines are in use and both require careful matching to obtain a reasonably low standing-wave ratio. Ratios of 1 to 1.25 have proven satisfactory for coaxial lines. A somewhat higher value can be tolerated on open lines.

Sleet and ice formation has been the most troublesome condition, resulting in flashover and occasional burn-out of the feeder system, a situation not too easy to repair under adverse conditions. De-icers have been built into some antenna installations and are especially valuable in zones subject to sleet formation. They are controlled from the power panel inside the building or can be made to operate automatically within the temperature range of sleet formation, and in no way affect the operation of the antenna. Without such protection it would be necessary to reduce the input power for transmission line protection.

The erection of coaxial lines sometimes is extremely difficult, especially vertical runs up a tower. Great care is essential to prevent solder and dirt from entering the line while under construction. Solderless inner and outer couplers have helped this situation considerably but on smaller sizes of line the inner couplers should probably be of the solder type. Several sections of line may be assembled on the ground and then hoisted into place, resulting in a minimum number of connections to be made up on the tower where it is harder to do good work.

Experience has shown the following transmission line sizes to be adequate for transmitter power outputs as listed below, assuming that the line is correctly terminated to eliminate standing waves:

250 watts or less	70 ohms 3/8 in. OD
250 watts to 1 kw	70 ohms 7/8 in. OD
1 kw to 3 kw	70 ohms 1-3/8 in. OD
3 kw to 10 kw	70 ohms 1-5/8 in. OD
10 kw to 25 kw	70 ohms 3-1/8 in. OD
25 kw to 50 kw	35 ohms 3-1/8 in. OD

Lines somewhat larger than are strictly necessary are suggested, giving additional safety factor. Larger lines also result in lower losses and may be advisable if the length of line is unusually long. For the STL transmission line sizes should be especially generous because at the higher frequencies involved losses increase appreciably and power is more difficult to generate. Figure 5 shows relative line loss at 50 Mc and 300 Mc for various sizes and lengths of typical coaxial line.

Transmitter Building

An f-m installation does not require as large a space as its a-m counterpart. A typical 1-kw f-m transmitter is a completely self-contained unit including blower and power supplies, occupying a space approximately 72 by 30 by 72 in. over all. A floor space as small as 350 square feet would be sufficient to accommodate the transmitter, and a room adjacent to the transmitter suitable for audio console, turntables, line amplifier, frequency and modulation monitor, and monitoring receiver. A typical 50-kw transmitter occupies space comparable to the average 5 and 10-

kw a-m stations now in service.

A typical 50-kw installation is the Milwaukee Journal f-m station WMFM, which houses its transmitter in a two-story building 47 by 34 ft in size. On the first floor shown in Fig. 6, is the transmitter, speech and test room, STL receiving room, caretaker's quarters and toilet. The basement, shown in Fig. 7, is devoted to the cooling and pump room, heating plant, work shop, tube storage and building utility. Rectangular steel ducts 4 by 6 in. are placed along the ceiling of the basement to house the inter-connect wiring between the various transmitter units directly above. All motor-generators, blowers, water pumps, etc. are mounted on rubber rails to minimize the noise transmitted through the building foundations.

The 50-kw transmitter comprises five units. The modulator is incorporated in the 250-watt unit, and followed by a 3-kw amplifier in a cabinet directly alongside, with its associated rectifiers and blowers. Following this is the high-voltage rectifier and power-control units mounted in racks somewhat larger. The plate transformer for the 100-kw rectifier, with its voltage regulator and reactor, is mounted directly outside the building on a raised concrete block platform for protection against snow. The 50-kw power amplifier is installed in a separate room which is completely shielded by 0.006-in. thick copper, including the floor and door.

A balanced concentric line consisting of two 3⅛-in. lines is inductively coupled to the power amplifier. These lines are mounted on an elevated trough spanning the distance between the tower and transmitter building. To minimize sudden differential changes between the inner and outer conductors, the trough is covered with a sectionalized, removable shield. Mounted directly at the transmission-line end-seals are two diodes which act as a vacuum-tube voltmeter reading the relative voltage for daily comparison and reference purposes. For the present, indirect measurement of power output is used and calculated at 60 percent of the plate input of the final stage.

The ground system deviates greatly from a-m band practice insofar as radial wires were not buried as a part of the radiating system and only sufficient copper was laid for equipment grounds and protection against lightning. The ground system consists of sheets of expanded copper screening each 6 by 10 ft in size, laid around the entire building and covered with eight inches of soil. The tower ground is made up of similar pieces forming a mat 30 by 30 ft overall and tied to the building ground by several two-inch copper straps.

During the period of construction, the entire building metalwork, such as conduit, water pipes, reinforcing steel, metal lathe, was bonded together and spot-welded. Every 10 feet, four-inch copper straps were brought out of the masonry slightly below ground level and joined to the screening.

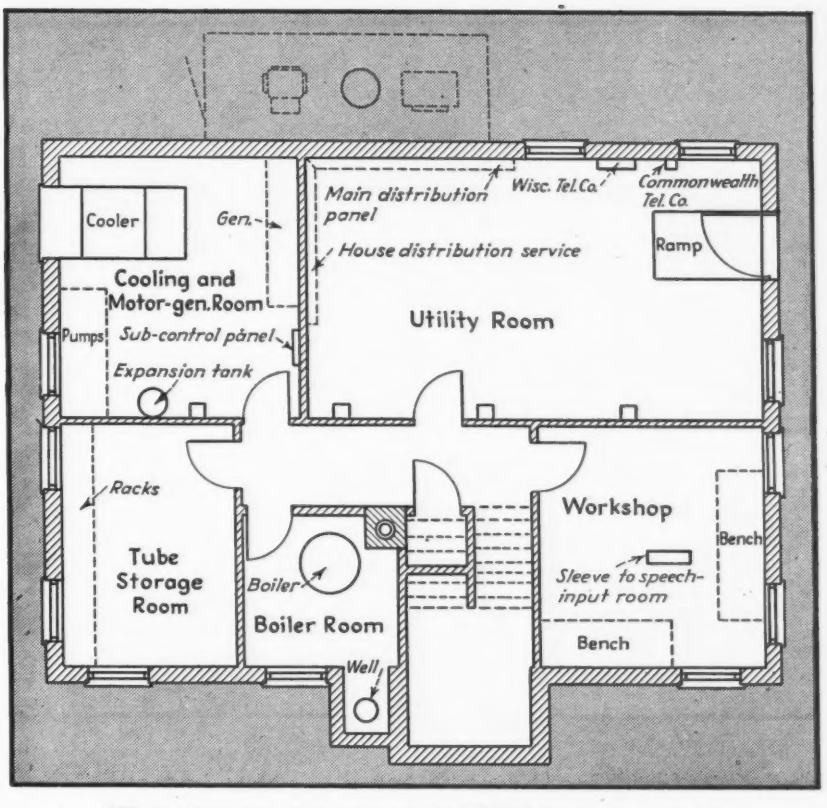


FIG. 7—Basement floor plan of the WMFM transmitter building

Power

The WMFM a-c power requirement for the transmitter itself is about 102 kva with the transmitter operating at its licensed power input of 60.5 kw. When the amplifier is running at full 50-kw r-f output, the a-c power demand rises to 135 kva. Power requirements given here do not include equipment such as the electric stove, building heating, water pump, tower and building lighting.

The local utility supplies service from either of two 26,400-volt lines, each line coming from a different direction on separate feeders. Three 50-kva transformers feed 240-volt, 3-phase power into the building through an underground duct.

Transmitters of various sizes will use approximately the following a-c power:

250 watts	1.2 kw
1,000 watts	3.5 kw
3,000 watts	7.5 kw
10,000 watts	24.0 kw
50,000 watts	135.0 kw

The power used by associated equipment such as speech input, monitoring, and lighting, should be added to the above estimated power requirements.

References

(1) A Report on the FCC Frequency Allocation Hearing, Electronics, p. 92, Dec. 1944.

(2) "Retail Shopping Areas," J. Walter Thompson Co., New York; "Four-Color Retail Trading Areas," Hagstrom Map Co., New York; "Trading Areas," Rand McNally & Co., Chicago; "Consumer Trading Areas," Hearst Magazines, Inc., New York.

(3) "Standards of Good Engineering Practice for High-Frequency Stations," Federal Communications Commission, Washington, D. C.

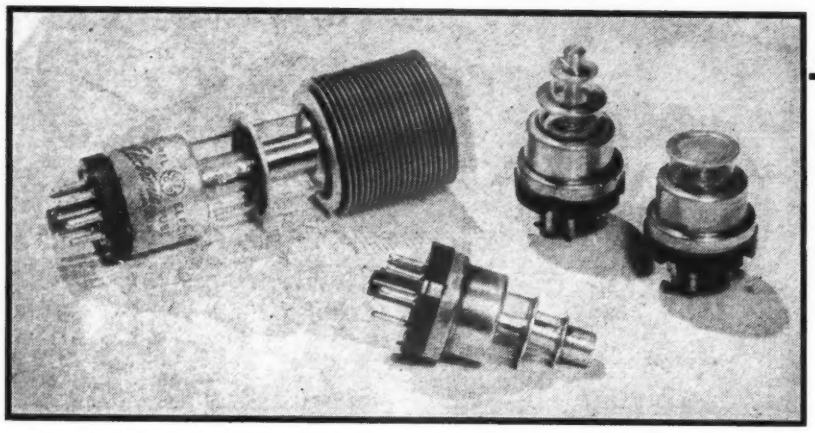


FIG. 1—Commercial disk-seal and lighthouse tubes

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DISK-SEAL TUBES

Altering conventional construction so that the tube elements become part of the electromagnetic circuit improves high-frequency operation. Disk-seal tube design places the electron stream in the high-impedance region of a cavity resonator

THE DEMAND for higher frequency and more power for new services and industries has grown as rapidly as research and development could push back the frontier. One of these outgrowths of research is the disk-seal tube. This new type tube, which includes that group known as lighthouse tubes, is a development that has greatly extended the usable frequency spectrum and introduced a new concept of the relation between the electron tube and its associated circuit.

The Basic Idea

Electronically, the disk-seal tube, or more simply the disk tube, is a multi-electrode tube using the same space-charge control principle as conventional triodes, tetrodes and pentodes.

Geometrically, it is a tube built from simple, smooth-surfaced disks and cylinders into a structure which usually, but not necessarily, has circular symmetry. As we shall see, the ultrahigh-frequency property of any such metal shape is a design factor whose significance is just becoming evident.

Philosophically, the disk tube is an embodiment of the principle that in the microwave field we can no longer speak of tubes and circuits as two distinct entities. It is necessary to think of a microwave oscillator, for example, not as an electron tube with an attached circuit but rather as a single electrical system having one section walled off and evacuated to house the electronic activity.

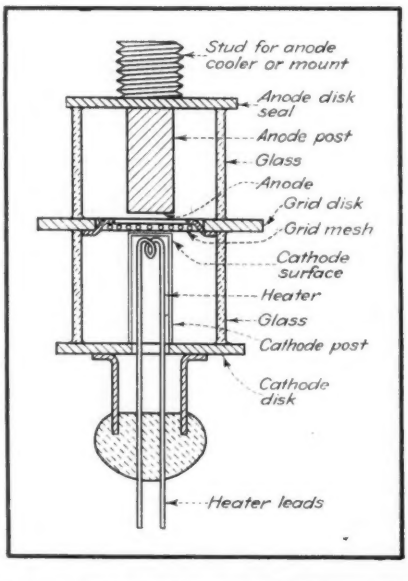


FIG. 2—Basic construction of disk-seal tube

A group of commercial disk tubes is shown in Fig. 1. Figure 2 is a cross-sectional view showing the basic mechanical features common to disk tubes. Figure 3 shows the constructional details of the 2C40 lighthouse tube.

Frequency Limitations of Conventional Tubes

In trying to reach the highest possible oscillation frequency with a given tube one usually starts at a low frequency, using some standard oscillator circuit such as the one in Fig. 4(a). The frequency is raised by decreasing L and C until the circuit looks like that in Fig. 4(b). A point is finally reached where the circuit has been made as small as possible and the tube is being operated at the maximum allowable plate power dissipation and voltage. The tube has reached its apparent maximum frequency.

Let us study the circuit arrangement in Fig. 4(c), which is the same as that in Fig. 4(b) but with the interelectrode capacitances and the lead inductances shown. If the

cathode is sufficiently isolated by the chokes, the radio-frequency potential of the cathode will be fixed with respect to the anode and grid by the two interelectrode capacitors C_{gk} and C_{pk}. Thus, the excitation or feedback voltage appears across C_{gk} and is not adjustable. When we include these two capacitors, it becomes clear that Fig. 4(b) is the familiar Colpitts oscillator circuit which we might expect to operate in the usual way if it were not for a number of new factors which creep in as we try to drive the frequency higher.

One reason why the frequency cannot be made higher lies in the indicated lead inductances and distributed capacitance of the electrode structures. In many cases, the main oscillating circuit is a two-wire transmission line connected to the grid and anode; a line which, in addition to its desirable features, has several serious drawbacks. One is that, although a quarter-wave line in itself is physically large even at very short wavelengths, the line is shortened by the interelectrode and stray capacitance of the tube elements until at some high frequency the part external to the tube vanishes.

Another factor is the increased energy losses due to the electromagnetic radiation from every part of the circuit. This becomes more severe as the tube electrodes and circuit elements become more comparable in size to the wavelength. Usually this tube radiation becomes so large that little or no useful output can be obtained, or it may even prevent oscillations from starting. This radiation is always a major limitation on the impedance which can be developed with an unshielded system.

Electron-Stream Transit Time

Still other difficulties arise from the electron transit time. When the electron transit time becomes comparable with the oscillation period, some properties of the electron stream which were negligible at low frequency become important. This does not mean that an insuperable barrier has been raised. It does mean that the system must be looked at in a far broader sense.

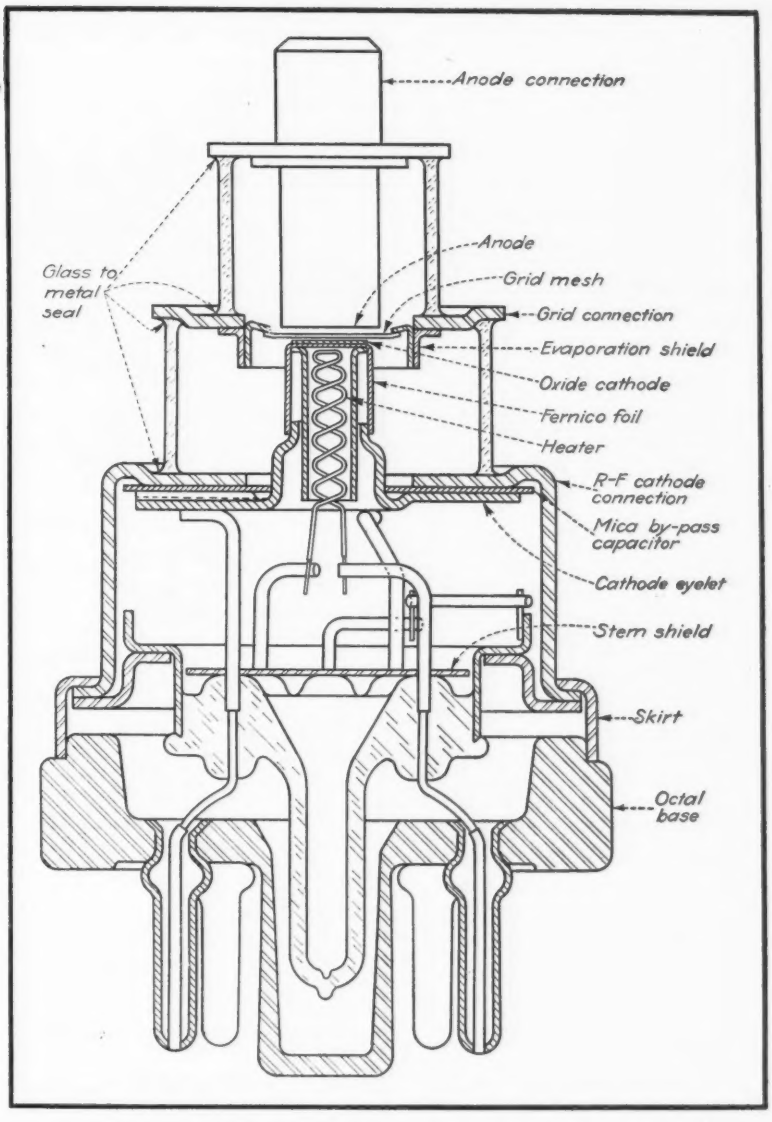


FIG. 3—Mechanical details of the 2C40 lighthouse tube

Because of transit time of the electron stream, there will be a dissipative load introduced at the excitation or input terminals of the circuit. There will also be a phase angle between the excitation voltage and the fundamental component of anode current such that the tube input and output voltages will almost never have the 180-degree phase relation common at low frequency. Phase angle as such need not be harmful provided we recognize and meet the added circuit requirements which it imposes. On the other hand, characteristics such as transconductance are adversely affected in comparison with d-c values so that there is an even greater need for efficient circuits than at low frequency.

The feedback circuit in the oscillator must be capable of providing the necessary excitation voltage in spite of the extra driving power, as well as almost any phase angle between its input and output voltages. But, with the arrangement shown in Fig. 4(c) the feedback voltage is almost entirely fixed both in amplitude and phase by the self and mutual reactances of the tube parts. None of these circuit elements can be adjusted and so above the frequency at which the phase relation between input and output becomes appreciably different than 180 degrees, the feedback conditions for sustaining oscillation cannot be met.

Use of Cavity Resonators

The frequency-determining circuit connected between grid and anode of Fig. 4(b) can be reduced

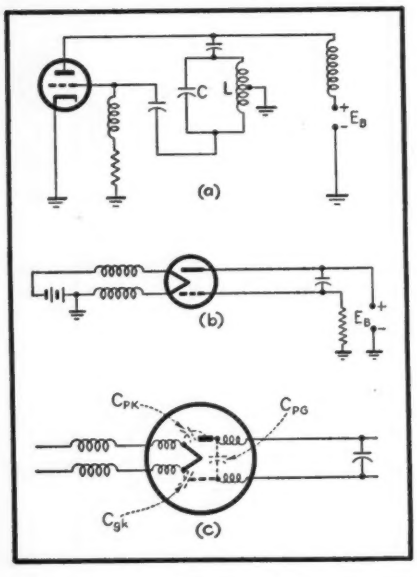
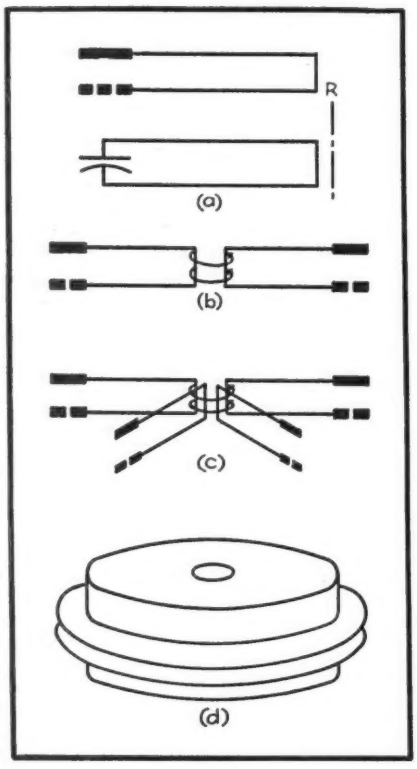


FIG. 4—At low frequencies, the lumped-constant oscillator circuit shown at (a) can be used. At higher frequencies the line oscillator shown at (b) replaces the lumped constant oscillator. At still higher frequencies the important circuit elements lie within the tube as illustrated at (c)

FIG. 5—At (a) the grid and plate are connected to a transmission line. The equivalent high-frequency circuit is shown directly below. (b) Two such circuits can be inductively coupled. Coupling an infinite number of such circuits gives the electrical arrangement shown at (c) and the mechanical arrangement shown at (d) which is in effect a figure of revolution of the equivalent circuit about the axis *R*



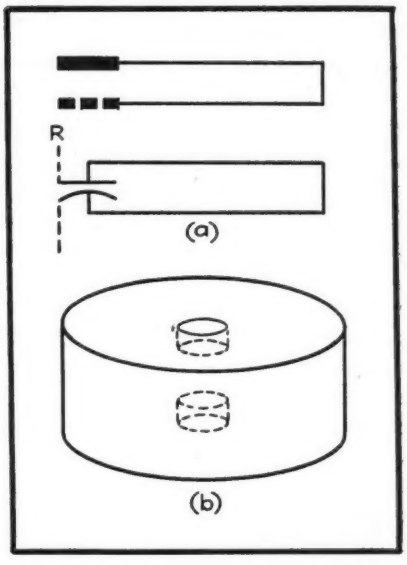


FIG. 6—Choosing a different axis of revolution from that of Fig. 5 for the equivalent circuit at (a) gives the mechanical arrangement at (b) which readily lends itself to use as the electromagnetic basis of the disk-seal tube; the electrodes for the electronic system go at the center

to a simple capacitance-shortened quarter-wave line by ignoring all direct-current parts of the circuit. Fig. 5(a) shows the simplified extract from Fig. 4(b) together with the equivalent circuit. We could have another tube and circuit coupled to this circuit at the high-current point as shown in Fig. 5(b). In fact, many such circuits could be added as at Fig. 5(c), the ultimate being equivalent to the rotation of the circuit at Fig. 5(a) about an axis *R* to give the structure shown in Fig. 5(d). The shortened quarter-wave line in Fig. 5(a) has, by rotation, generated a closed metal structure made of two parallel flat metal disks joined by a cylindrical hub at the center and terminated at the periphery by an annular ring capacitor.

Continuing the same line of thought gives rise to other structures such as that in Fig. 6. Such totally enclosed circuits or cavity resonators are ideally suited to ultrahigh-frequency needs. The one shown in Fig. 6, for example, would be expected to have much the same current and voltage distribution as do the quarter-wave line sections from which it was developed and which make up its radii.

This is a sound physical picture but inaccurate numerically. A more exact analysis must be based on the electrical properties of the geometrical shape. A simple radial resonator and a quarter-wave open line are shown in Fig. 7, together with the current and voltage distribution for each. In the uniform open line, the resonant line length is 0.25 λ, whereas in the resonator the radius is 0.38 λ.

The most important distinction between line and cavity is that the hollow resonator of Fig. 7 is self shielding. The electric and magnetic fields exist wholly within the resonator. If the metal walls of the resonator are made a few times thicker than the skin thickness or depth of field penetration, there will be no appreciable coupling between the space inside and that outside the resonator and, therefore, there will be no energy lost by radiation.

Union of Tube and Tank

If cavities are to be used to their fullest advantage, the electronic part and the electromagnetic part of the circuit must be considered as a unit. The disk tube brings about this union in a way illustrated by Fig. 8. Fig. 8(a) shows a vertical cross section of a simple radial resonator similar to that developed in Fig. 6. The point of maximum impedance occurs internally between the two surfaces, *S*. It is here that the grid and anode connections would be made if the cavity were to be used in place of the open wire line of Fig. 4(b).

The genesis of the disk tube is obvious from here on, for, if the surfaces *S* are proper for grid and anode connections, it would be even better if they became the actual grid and anode electrodes. Fig. 8(b) shows the development of such electrodes and Fig. 8(c) shows a section of a resonator containing the electrodes walled off and evacuated to form the upper part of the disk tube illustrated in Fig. 2. The electronic circuit element has been coupled directly to the electromagnetic circuit element with very little geometric disturbance to either component. There is no anode- or grid-lead inductance in the ordinary sense. Neither is there unwanted capacitance except that due to the active part of the electrodes. All of these metal surfaces help to shape and contain the electromagnetic field. By maintaining sub-

stantial continuity of the metal surfaces, the tube elements become an integrated part of the circuit.

Controllable Feedback

The use of a cavity resonator goes a long way toward solving the problems posed by the output circuit of our sample oscillator but some other problems—feedback for example—have not yet been touched.

It was pointed out that one reason why the circuit of Fig. 4(c) fails is that it allows no adjustment of either the amplitude or phase of the feedback voltage. The essentials of this circuit are redrawn in Fig. 9(a) using lumped circuits and showing the interelectrode capacitances which fix the feedback voltage.

A considerable amount of control can be gained by including C_{pk} in a tuned circuit as shown in Fig. 9(b). This tuned input circuit

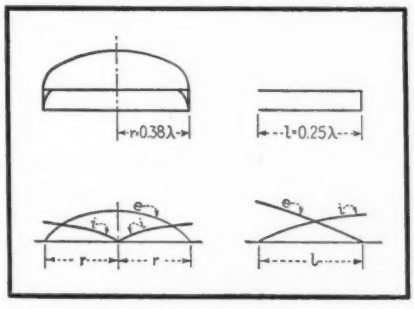


FIG. 7—Resonant dimensions of a cylindrical cavity and a transmission line, and the current and potential distribution of each

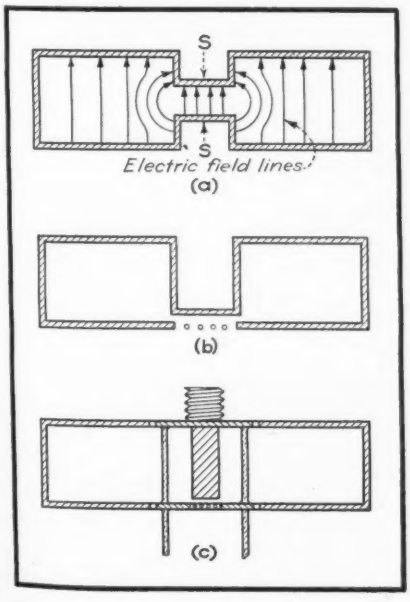


FIG. 8—The evolution of the disk-seal tube from a cavity resonator

should be a cavity resonator for the same reasons which prescribe a resonator for the output circuit. Frequently C_{pk} is not large enough to provide adequate feedback and, in that case, it is supplemented by an added adjustable link.

Figure 10, which shows two resonators having a common central wall, illustrates the general mechanical combination of a disk tube and a double resonator which has come to be known as the grid-return, grounded-grid or, more properly, the grid-separation circuit.

An important attribute of the disk tube is the physical separation of the input and output circuits which it permits. This is important because physical separation means electrical separation since, even though the central cavity-dividing wall and the grid disk are common to both resonators, the small depth of field penetration into this wall effectively keeps the electromagnetic fields within their own cavities. In other words, C_{pk} is the only coupling reactance left; the dozens of small coupling capacitances and mutual inductances between electrode parts and leads in conventional tube designs are eliminated.

If it is desirable—and it is in some cases—C_{pk} may be made inconsequential by adding a screen grid.

Through these features, the disk tube permits the use of distinct input and output circuits; the feedback circuit between the two is reduced to a known impedance and the various circuit parameters brought under individual control. These circuits have been the subject of much intensive study, both theorectical and physical, and several basic forms have been evolved.

Electromagnetic Shielding Provides Heat Radiation

Figure 11 shows a cavity oscillator circuit. The mechanical layout of this circuit illustrates another very important property of the disk tubes. At very high frequencies, the electric field within the resonator and between electrodes penetrates the metal surfaces a distance in the order of only about one thousandth of an inch and therefore the current conduction is entirely confined to those surfaces which are exposed

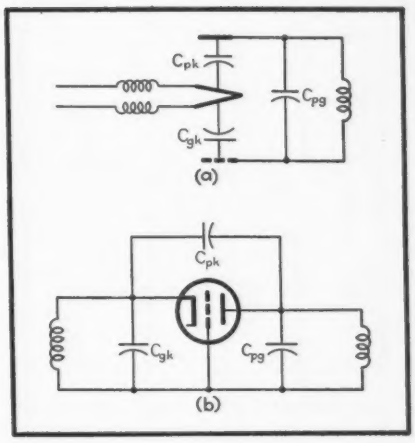


FIG. 9—The circuits used with the disk-seal tube take advantage of the interelectrode capacitances shown in drawing (a) by placing them in the resonant circuits as at (b)

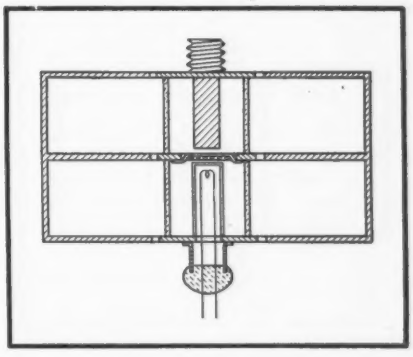


FIG. 10—The disk-seal tube and resonator equivalent of the lumped-constant circuit shown at Fig. 9 (b)

to the electric field. Thus, there will be high frequency electric currents flowing on the inner surfaces of the resonators and none on their outer surfaces. One might say that the inner and outer surfaces are insulated. Heat, on the other hand, does penetrate the resonator walls and is conducted throughout the metallic circuit. These differing laws of behavior are the source of a most advantageous function which occurs automatically in the disk tubes.

In the disk tube, high-frequency energy flows from its point of origin on the anode surface into the resonator. On the other hand, heat generated at the anode flows through the solid anode rod to the outside of the resonator. This automatic filtering permits anode cooling to be carried out by any appropriate method outside the cavity without interfering in any way with the high-frequency part of the system inside the cavity. The

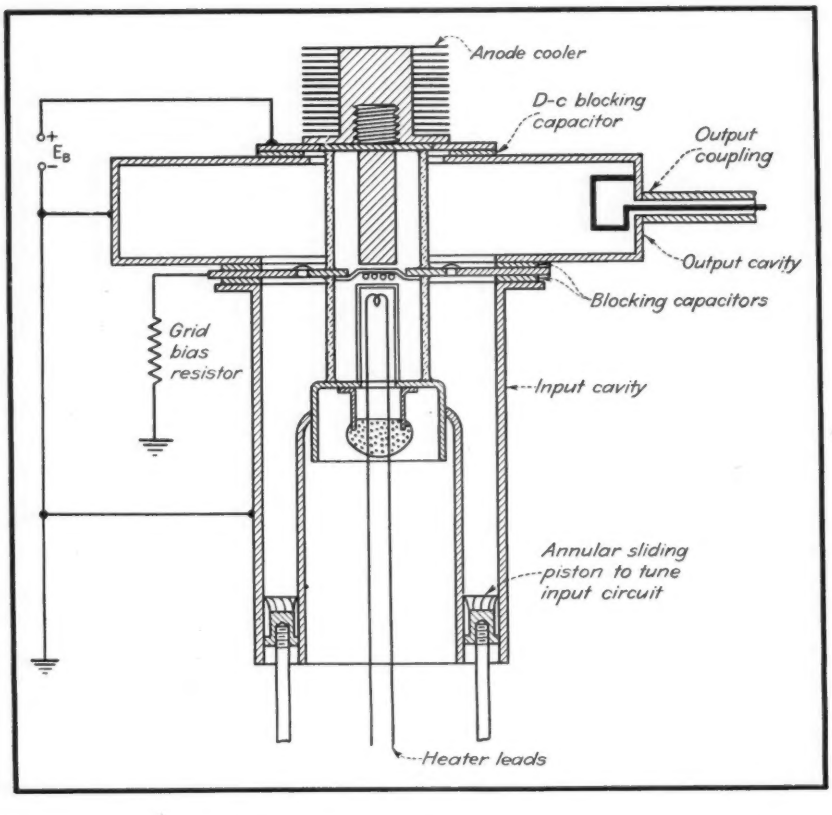


FIG. 11—Mechanical layout of a disk-seal tube circuit shows unity of the tube proper with the wave circuit

grid is cooled in the same manner so that troubles arising from primary grid emission are greatly reduced.

Since the same reasoning applies in reverse, it is possible to locate the cathode heater together with all its power supply wiring wholly outside the cavities and free of ultrahigh-frequency field.

The same filtering occurs with direct current or low-frequency alternating current and therefore power connections can be made to the cavity system without the use of elaborate isolating chokes.

Design Requirements

Mechanically the disk seals in many of these tubes are made of a metal suitable for sealing to glass. High electrical conductivity is preserved by a thin coating of copper or silver which, since it need be only a few thousandths of an inch thick, will not cause dangerous stresses in the vacuum seals. Again we take advantage of the small field penetration to fabricate a composite structure having good electrical conductivity as well as suitable mechanical properties.

The parallel-plane electrodes offer an opportunity as well as pose a problem. To make efficient microwave tubes it is important to use the electron stream efficiently. The degree to which desirable electronic properties are achieved may be judged by one or more of several criteria depending on the type of service considered. For instance, we are always interested in low interelectrode capacitance and yet for a power amplifier we must not sacrifice current-carrying ability. For this application we might use the ratio C/i_p as a figure of merit. For low level amplifiers, where power gain and electron noise are important, we want the highest transconductance possible for a given current. Here we are interested in a large ratio of G_m/i_p. For some jobs, interest will center on power gain and bandwidth. In almost every case, it is desirable that the transit angle be kept small.

Manufacturing Tolerances

When we examine the various criteria, we find generally that they are all improved by decreasing the interelectrode spacing, particularly the grid-cathode spacing. The end-on presentation of plane electrodes is an arrangement uniquely suited to this need. The electrodes require accurate positioning in only one major dimension rather than two as would be the case for cylindrical electrodes. Tube construction and assembly methods enable a tube like the 2C40 to be built with a cathode-grid spacing of 4.0 mils. Developmental tubes have been built with only 1.0 mil cathode-to-grid clearance.

If space-charge control of the usual type is to be retained, the grid-wire size and pitch must be reduced in proportion otherwise it will become so coarse relative to the reduced interelectrode spacing that the electric field will become nonuniform between the grid and cathode. Under this condition, the low-frequency characteristics are poor and the high-frequency characteristics suffer even more severely from the resulting multiplicity of transit angles.

Even more important is the need for keeping the electrodes parallel within rather small limits. The damage due to non-parallelism can be seen if one considers that, in tubes in which the transit angle is fairly large and the electrodes are misaligned, the current from one element of cathode area can have a quite different phase angle from that of neighboring areas. Since the high-frequency components of current from these elements add vectorially, the resultant alternating current may be quite small and bear no relation to the low-frequency or static characteristics of the tube.

Liberal credit is due the members of the Naval Research Laboratory and the Camp Evans Signal Laboratory who not only expedited the development work by their active interest and early support but helped apply the results with satisfying effect.

Many men have contributed much to many phases of this work but more than ordinary credit is due Mr. R. J. Bondley and Mr. J. E. Beggs, who have been associated with the work almost from its inception and who, through individual effort and contribution, have solved many of the basic design problems in these tubes.

Measuring the Elasticity of SYNTHETIC YARNS

Young's modulus is determined with a minimum of error due to plastic deformation. Fiber under test is excited at 10 kc per second, producing high-loading under short-period conditions. Method also lends itself to testing of plastic films and other materials

By SHIRLEIGH SILVERMAN* and J. W. BALLOU**

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AS THE SYNTHETIC textile industry has grown from its early days when rayon was considered merely artificial silk, to the status of a widespread, self-sufficient industry, it has become more and more important to understand and to measure inherent physical properties of new man-made yarns. This is particularly true of yarns intended for such things as tire-cords, where physical properties are involved which never before were of much importance.

At the present time, empirical testing is usually resorted to in the end, for lack of ability of the usual stress-strain curve to impart information which closely correlates with observed practical performance. However, since it was felt that the elastic properties of a string under tension are fundamental characteristics of the system, it was decided to develop a technique for measuring the elastic modulus in an unambiguous manner. The modulus likely to be of primary interest is Young's modulus, defined as

$$E = \frac{\text{force per unit cross section}}{\text{elongation per unit length}}$$

In dealing with systems that exhibit both plasticity and elasticity, such as fibers and films, the usual methods of measuring Young's modulus are apt to give results highly influenced by the presence of the plastic component since, in general, a low rate of loading is employed. When a load is applied slowly to such a medium, plastic deformation is observed, i.e., complete recovery is not present after the release of the stress.

Young's modulus may be determined from the slope of the ordinary strain curve. But in a good many cases the resultant stretching produces a change of structure, e.g., by increasing the orientation; and it is for these reasons that the usual mechanical methods are not

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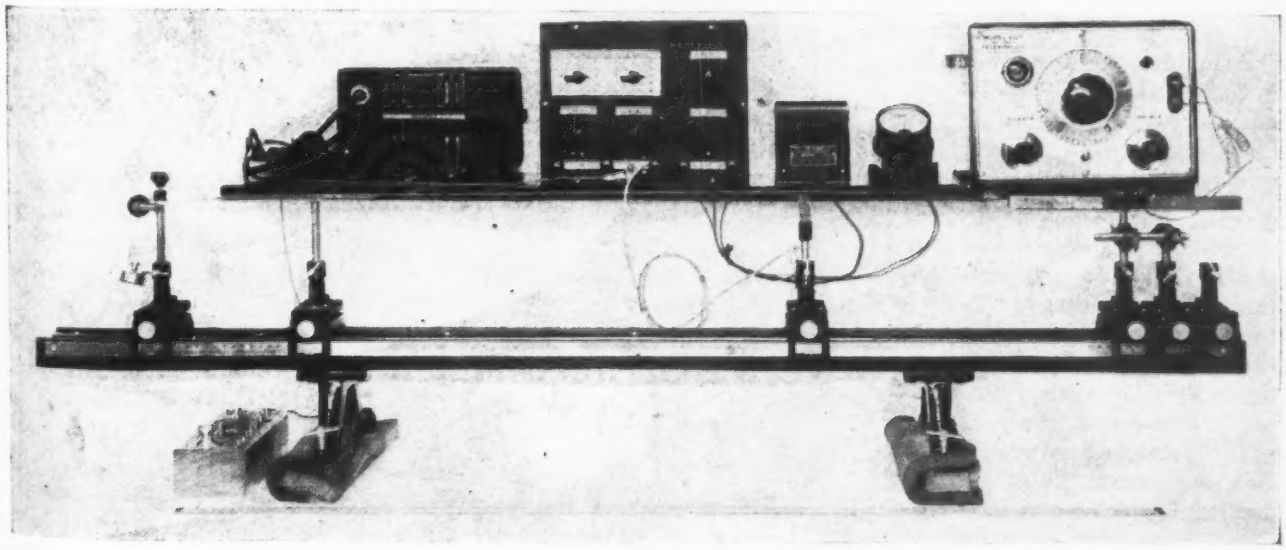

Photograph of the test setup used by the authors. The various component parts of the system are identified in the schematic of Fig. 1, appearing on the next page

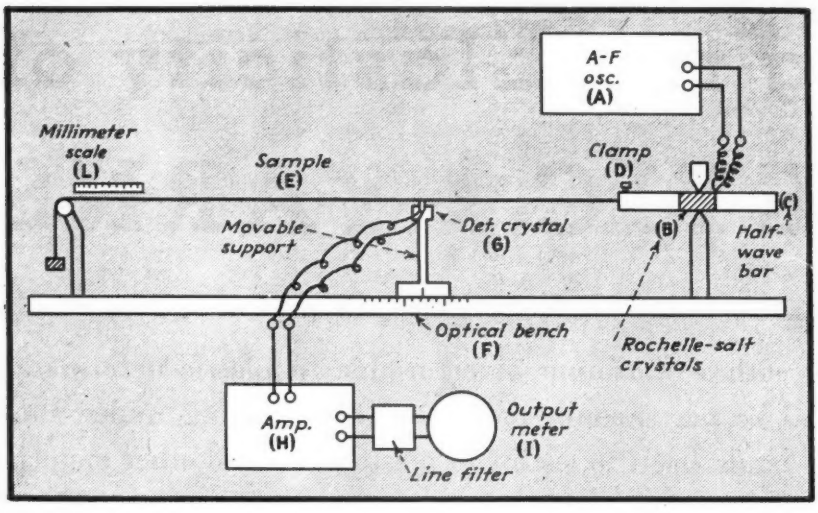

FIG. 1—Schematic of the setup used to measure the elasticity of synthetic yarns and plastic films by a method described in the text. A photograph of the equipment appears on the preceding page

adapted to a study of the truly elastic characteristics of fibers and films. Also, it is difficult to apply some of the methods, such as those based on compression, impact and photo-elastic effects.

To study the elastic component alone requires a high rate of loading so that the deformation is executed very rapidly, thereby minimizing the relaxation and plastic processes. The problem of obtaining this high rate of loading for such measurements was solved by the use of longitudinal vibrations of relatively high frequency, around 10 kc, an application of sound waves used previously by Meyer and Lotmar[1] but in a less versatile form than that described in this paper.

Method

The method is based on the expression for the velocity of sound in media which are free to shrink laterally when extended longitudinally and expand laterally when compressed longitudinally, that is:

$$V = \sqrt{E/d} \qquad (1)$$

where E is Young's modulus of elasticity, and d is density of the medium. From this it can be seen that E, the adiabatic modulus, can be calculated if V and d are measured. This is what was done in the present case with continuous fiber samples and very narrow film strips. It was assumed that this formula applied to such materials without corrections, which is probably defensible particularly in the case of the fibers which were usually made up of filaments of very small cross section.

It is a fortunate thing that V is independent of the fiber cross sectional area, thereby making it unnecessary to measure cross section accurately. This is a distinct advantage not found in the usual methods for measuring Young's modulus. It was necessary to know the density of the fibers and films tested, but the literature provided reliable values in most cases.

Standing waves of a definite frequency were set up in the sample and the half-wavelengths measured. Knowing the frequency, the velocity was then calculated.

Remembering the usual relation for wave motion: $V = n\lambda$, where V is velocity of sound, n is frequency of vibration, and λ is wavelength, we get, by substituting in Eq. (1).

$$E = n^2\ \lambda^2\ d = 4\ n^2 d\ (\lambda/2)^2 \qquad (2)$$

Equipment

In the equipment illustrated in the photo and shown schematically in Fig. 1 the source of the longitudinal vibrations is a halfwave bar of steel (C) cut to resonate at 10 kc. Two Brush rochelle-salt crystals (B) cut to respond at the same frequency are cemented to opposite sides of the bar. The whole system is excited to resonance by a Televiso VG-1 audio oscillator (A). The particular bar and crystal combination used gave a not-too-broad resonance at 9.4 kc with sufficient amplitude for measurements with only a few volts oscillator output.

The sample of film or fiber (E) was clamped at (D) and its elongation read from the millimeter scale (L). The sound source, along with the pulley and clamp at the other end, was mounted on an optical bench (F) and the sample was run over the pulley and loaded by a weight to give the desired tension or clamped at the desired elongation.

A rochelle-salt crystal (G) of the type commonly used in high-fidelity phonograph pickups was mounted in a support which could move along the optical bench; the crystal wafer had a small steel wire imbedded in its waxed edge to serve as a bearing surface for the yarn or film sample.

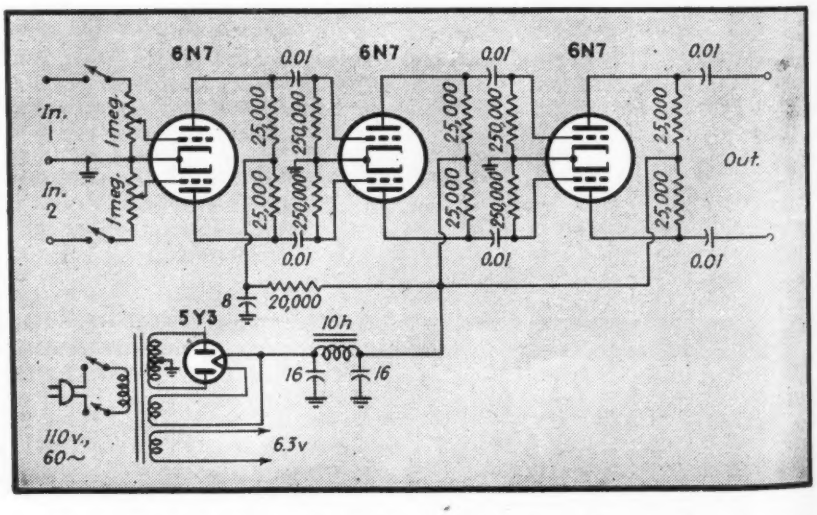

FIG. 2—Circuit of the audio amplifier employed. Only one channel was used in the experiments described. The second channel was provided to facilitate a proposed direct-reading scheme utilizing a phase-meter

The pickup crystal acts both as a reflecting fret and detector of the amplitude of standing waves when these are set up. The crystal pickup feeds into one channel of an amplifier (H) whose circuit is shown in Fig. 2. The amplifier output is filtered through a General Radio 614-P3 60-cycle line filter to a Triplett output meter (I).

The crystal pickup offers a sufficient discontinuity so that some of the energy in the sample is returned of the source. When this returned energy is in phase, standing waves are formed and an intensity increase, as shown by the output meter, occurs. To determine the half-wavelength, the position of the movable crystal support on the optical bench is noted for two successive maxima, the difference then being the required value. This scheme is preferable because end effects cancel out.

Operation

In operating the setup, the sample is put in under a definite load or elongation. The detecting crystal is adjusted for height so that good contact with the sample is insured. This adjustment is very important and some practice is required in finding the optimum condition.

The position of the detecting crystal, the amplifier gain and the oscillator output are next adjusted so that a signal of a volt or so appears on the meter. The oscillator frequency is then adjusted for resonance as indicated by a peak in the meter reading at this arbitrary setting of the pickup.

Next the detecting crystal is moved along the optical bench until an absolute peak is found, meter readings every 1 mm are taken and the peak is accurately located. The detecting crystal is then moved on to the next peak and a similar bracketing measurement made.

The small millimeter scale was used for measuring sample elongation under various loads, using a fiducial mark on the sample.

In working with fibers, any twist above three turns per inch was removed before measurements were made. It was found necessary to load all samples initially by a small amount to get good maxima readings. This was done in all cases and the elongation was calculated using the length at this loading as the original length. In general, cords twisted from strands could not be tested as the surface was too irregular.

In working with films such as cellophane, a strip a few mm wide was cut in the desired direction and put in under a load of 100 g. As before, if the sample was stretched, the length at this load was taken as the original length.

To facilitate routine use of this method, graphs were prepared for each common density used, the modulus being plotted vs the half-wavelength at the operating frequency. The half-wavelength encountered in the tests ranged from 5 to 30 cm. It was found practical to train an operator to use the setup for routine testing, and it is hoped in the future to be able to adapt the arrangement to a direct-reading scheme—perhaps by use of a suitable phase-meter. For this future eventuality, the amplifier was built with two matched channels, although only one channel was used in work covered in this report.

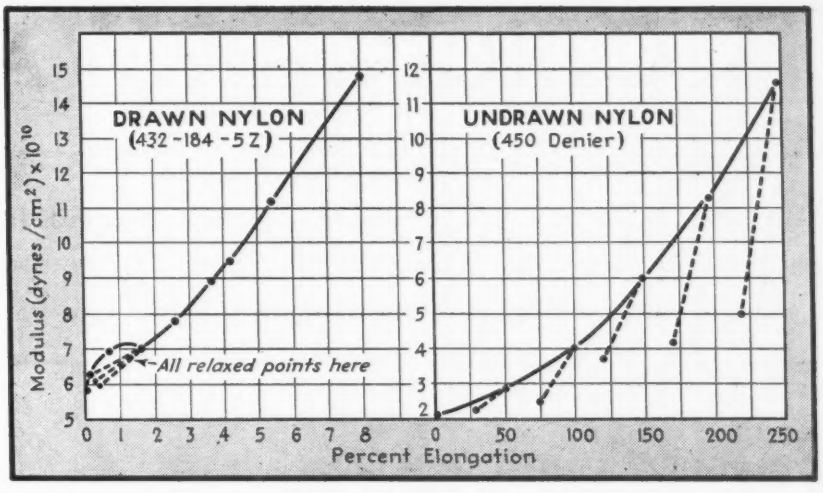

FIG. 3—Graphs showing characteristic behavior of a Nylon polymer yarn, depicting the change in modulus introduced by a drawing operation which orients the yarn and forms it into a tough resilient material

Results

The apparatus was first proved-in with steel and copper wires. For such materials, sound velocities checked with International Critical Table values to ±1 percent. No trace of transverse vibrations was found; this was gratifying but expected, since the range of transverse vibrations for the tensions, lengths and linear mass densities encountered is more than an order of magnitude below 10 kc.

Of the materials investigated (a more complete summary is to be found in the reference) the following values were found:

Materials	dynes/cm²
Copper—annealed wire	12×10^{11}
Steel piano wire	20×10^{11}
Linen	36×10^{10}
Rayon tire cord	21×10^{10}
Human hair	$6–7 \times 10^{10}$
Silk	19×10^{10}
Cellophane film	$5–12 \times 10^{10}$

The characteristic behavior of a Nylon polymer yarn is shown in Fig. 3. This depicts the change in modulus introduced by the drawing operation which orients the yarn and forms it into the tough resilient material so well-known to the textile trade. The dotted lines show the behavior when the tension is relaxed.

Conclusion

This method for modulus measurements has much to recommend it. It is simple, direct and rapid. The sample is not damaged and its behavior may be observed through a predetermined cycle. Its applications to the study of elastomers in the synthetic rubber industry, as well as to wire and many other phases of metallurgy are indicated, in addition to its potential usefulness in the textile field itself.

Reference

(1) Meyer, K. H., and Lotmar, W., The Elasticity of Cellulose, *Helvetica Chimica Acta*, 19, 68-86, 1936.

CIRCULAR WAVE GUIDE

To facilitate the design of exciting elements and grids for filtering particular modes, field patterns for five modes having the lowest cut-off frequencies are plotted. Diagrams show direction and relative magnitude of fields in the transverse plane

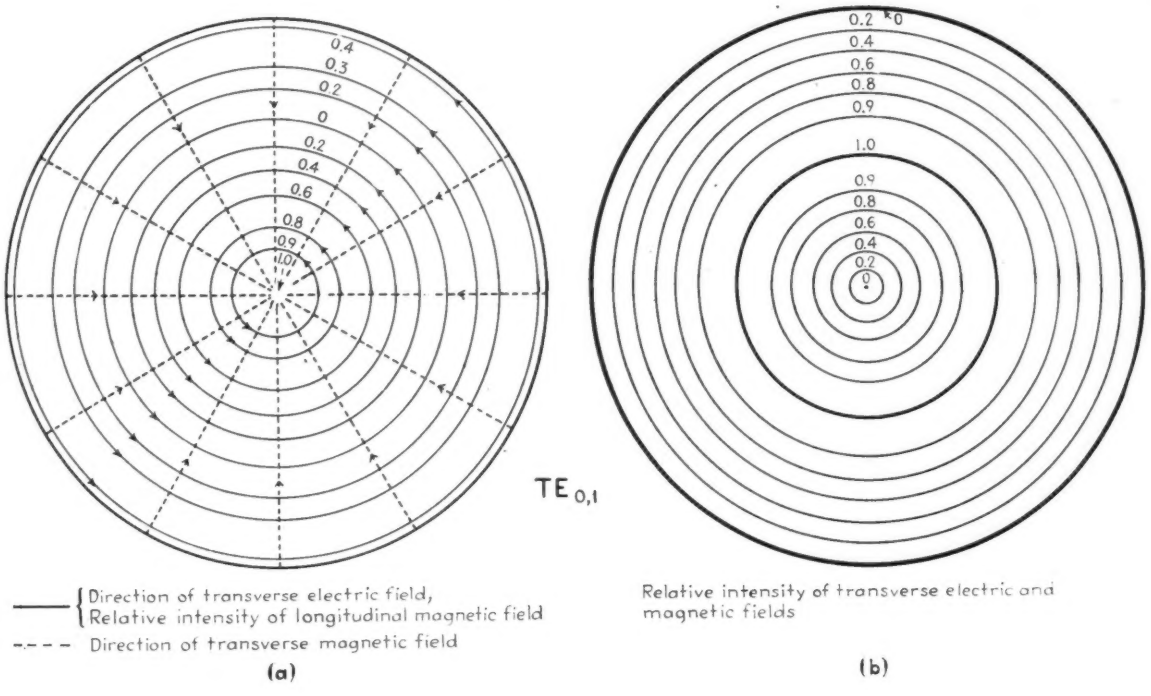

FIG. 1—The wave guide field pattern of the simplest transverse electric wave

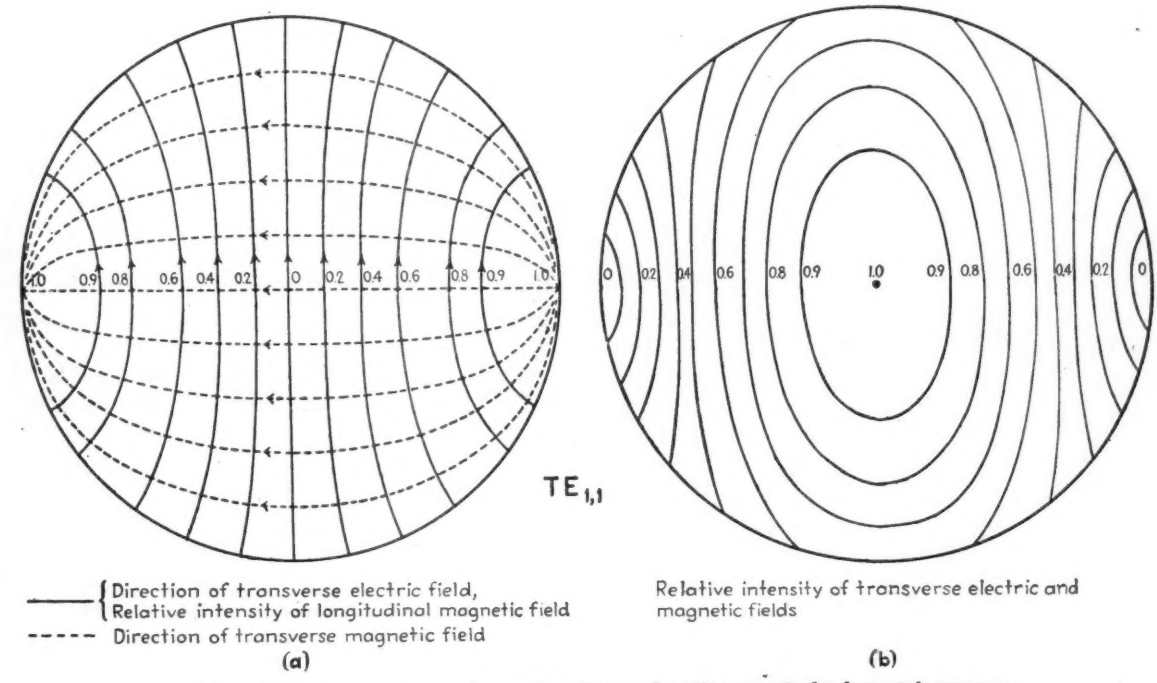
1.0 0.9 0.8 0.6 0.4 0.2 0 0.2 0.4 0.6 0.8 0.9 1.0
TE 1,1
0 0.2 0.4 0.6 0.8 0.9 1.0 0.9 0.8 0.6 0.4 0.2 0
Direction of transverse electric field,
Relative intensity of longitudinal magnetic field
Direction of transverse magnetic field
(a)
Relative intensity of transverse electric and magnetic fields
(b)

FIG. 2—For a given wave guide radius, this mode will transmit the lowest frequency

FIELDS

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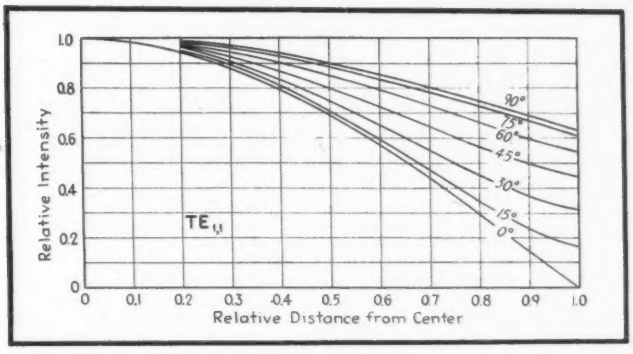


FIG. 3—As an aid to plotting relative transverse field intensity, this intermediate graph is used

THE diagrams presented in this paper describe the electric and magnetic fields inside circular wave guides for certain modes of transmission.

For each mode considered there are curves showing the direction and relative intensity of the transverse fields and the relative intensity of the longitudinal field. The direction of the longitudinal field is, of course, always along the axis of the guide.

The five modes of transmission presented here are those which have the lowest cut-off frequencies.

Applications of Field Patterns

These curves find practical application in designing many types of wave guide equipment. For example, the design of devices for initiating and receiving the various modes, either independently or simultaneously in a single guide, is aided by a knowledge of the locations of regions of maximum field strengths and their associated directions.

Likewise, the design of filters for passing a desired mode or modes and attenuating undesired modes is materially aided by this information. A further use might be the design of coupling units of all sorts. One application in which these curves have been of considerable benefit is the design of a transducer for changing from one mode of transmission to another.

The curves are of considerable theoretical interest and it is hoped that they will add to the existing knowledge of wave guide transmission.

TE Field Equations

In a circular, air-filled guide of perfect wall-conductivity at a frequency well above the cut-off frequency, the transverse electric waves ($TE_{n,m}$) are defined by the following equations:

$$E_z = 0 \tag{1}$$

$$H_z = AJ_n(K_m' r/a)\cos(n\theta)\cos(\omega t - \beta x) \tag{2}$$

$$E_\theta = (377A)(f/f_0)[J_n'(K_m' r/a)\cos(n\theta)\sin(\omega t - \beta x)] \tag{3}$$

$$H_r = -A\sqrt{(f/f_0)^2 - 1}\,[J_n'(K_m' r/a)\cos(n\theta)\sin(\omega t - \beta x)] \tag{4}$$

$$E_r = (377A)(n/K_m')(a/r)(f/f_0)[J_n(K_m' r/a)\sin(n\theta)\sin(\omega t - \beta x)] \tag{5}$$

$$H_\theta = A(n/K_m')(a/r)\sqrt{(f/f_0)^2 - 1}\,[J_n(K_m' r/a)\sin(n\theta)\sin(\omega t - \beta x)] \tag{6}$$

where

E = the electric field intensity in volts per meter along the axis indicated by the subscript
H = the magnetic field intensity in ampere-turns per meter along the axis indicated by the subscript
A = a constant determining the maximum amplitude of the field
a = the diameter of the guide
r/a = the relative radial distance from the center of the guide
x = the distance along the axis of the guide
θ = the angle in the transverse plane
$J_n(\ )$ = the Bessel function of the first kind of order n
$J_n'(\ )$ = the first derivative of $J_n(\ )$ with respect to its argument
K_m' = the mth root of $J_n'(K) = 0$
f_0 = the cut-off frequency
f = the frequency of transmission
$\omega = 2\pi f$
β = the phase shift in the guide in radians per meter

In these equations the factors which determine the phase of the components are of no importance in calculating the field direction and relative intensity beyond indicating that all transverse components are in phase. For that reason these factors are omitted throughout the following discussion.

The direction of the transverse electric field is given at every point inside the guide by the differential equation

$$r\,d\theta/dr = E_\theta/E_r \tag{7}$$

If the expressions for E_θ and E_r from Eq. (3) and (5) are substituted in Eq. (7) and the integration carried out the resulting equation is

$$J_n(K_m' r/a)\cos(n\theta) = C \tag{8}$$

where C is an arbitrary constant. Except for a constant multiplier, the left side of this equation is also the expression for H_z. Therefore, Eq. (8) defines a family of curves which at every point determines the direction of the transverse electric field and also, with appropriate choices of C, give the contours of relative intensity for the longitudinal magnetic field, H_z.

The results of evaluating Eq. (8) for the $TE_{0,1}$, $TE_{1,1}$, and $TE_{2,1}$ modes are shown by the solid lines in Fig. 1(a), Fig. 2 (a), and Fig. 4(a) respectively. The number near each line is the relative intensity of H_z for that particular contour. The tangent to the line at any point is the direction of the transverse electric field at that point.

The same figures also show with dotted lines the direction of the transverse magnetic field. These curves are not calculated but are simply sketched in as the orthogonal trajectories of the first set. In fact, calculated curves for the $TE_{1,1}$ and $TE_{2,1}$ modes would be difficult to obtain as the family is represented mathematically by a slowly convergent infinite series.

Determination of Relative Transverse Field Intensity

The next items of interest are the contours of relative intensity for the transverse electric and magnetic fields. In the case of the $TE_{0,1}$ mode where E_r is zero, these curves are easily obtained by setting the expression for E_θ equal to an ap-

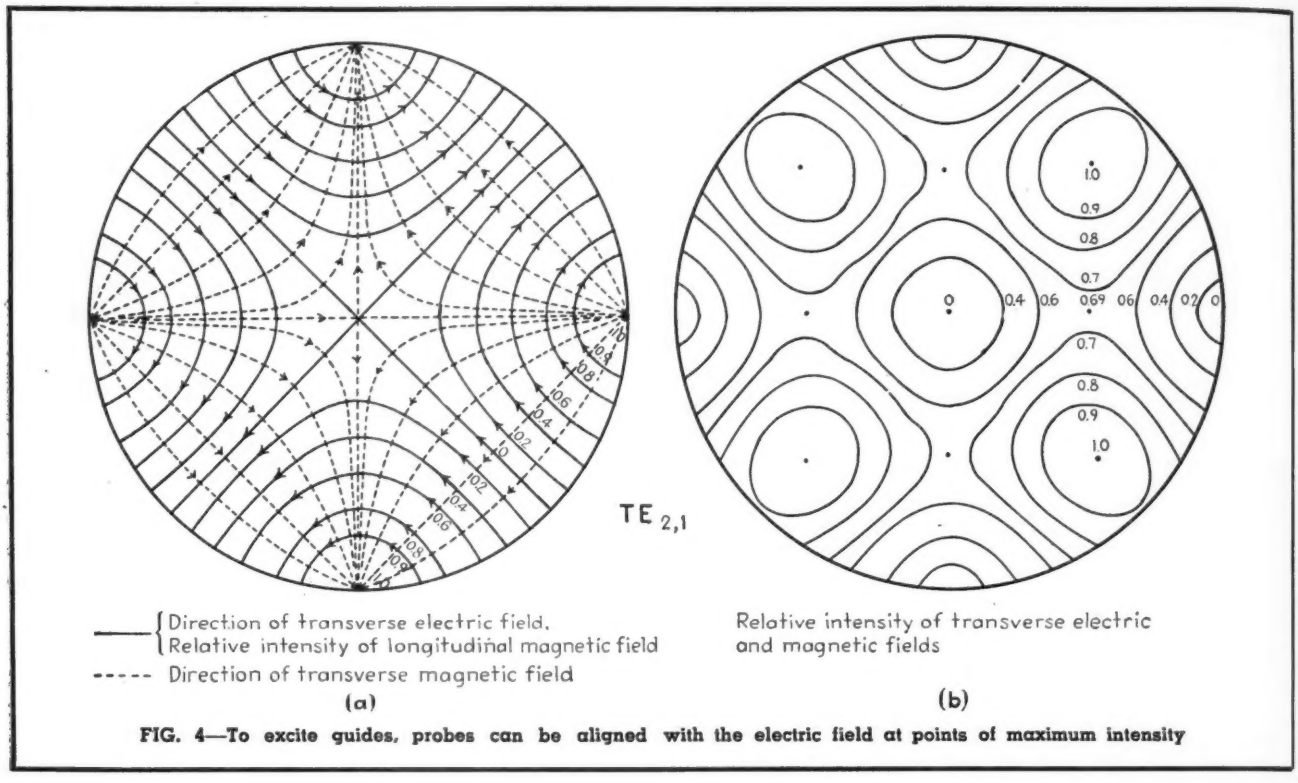

TE 2,1
Direction of transverse electric field,
Relative intensity of longitudinal magnetic field
Direction of transverse magnetic field
(a)
Relative intensity of transverse electric and magnetic fields
(b)

FIG. 4—To excite guides, probes can be aligned with the electric field at points of maximum intensity

propriate set of constants. The results are shown in Fig. 1(b).

For the $TE_{1,1}$ and $TE_{2,1}$ modes the problem is more difficult as there are two components to consider and the total transverse field is the resultant of these two. The first step is to evaluate E_θ and E_r for a number of values of r/a and θ and to find the resultant field by taking the square root of the sums of the squares of these two components. The resultant values, expressed as relative intensity, are then plotted as a function of r/a with θ as a parameter. These intermediate curves are shown in Fig. 3 and Fig. 5. From these curves it is possible to read the values of r/a and θ needed to plot the contours of relative intensity. These contours are shown in Fig. 2(b) and Fig. 4(b).

Although the contour intensity curves were calculated from the electric field equations, they apply equally well to the transverse magnetic field because of the constant

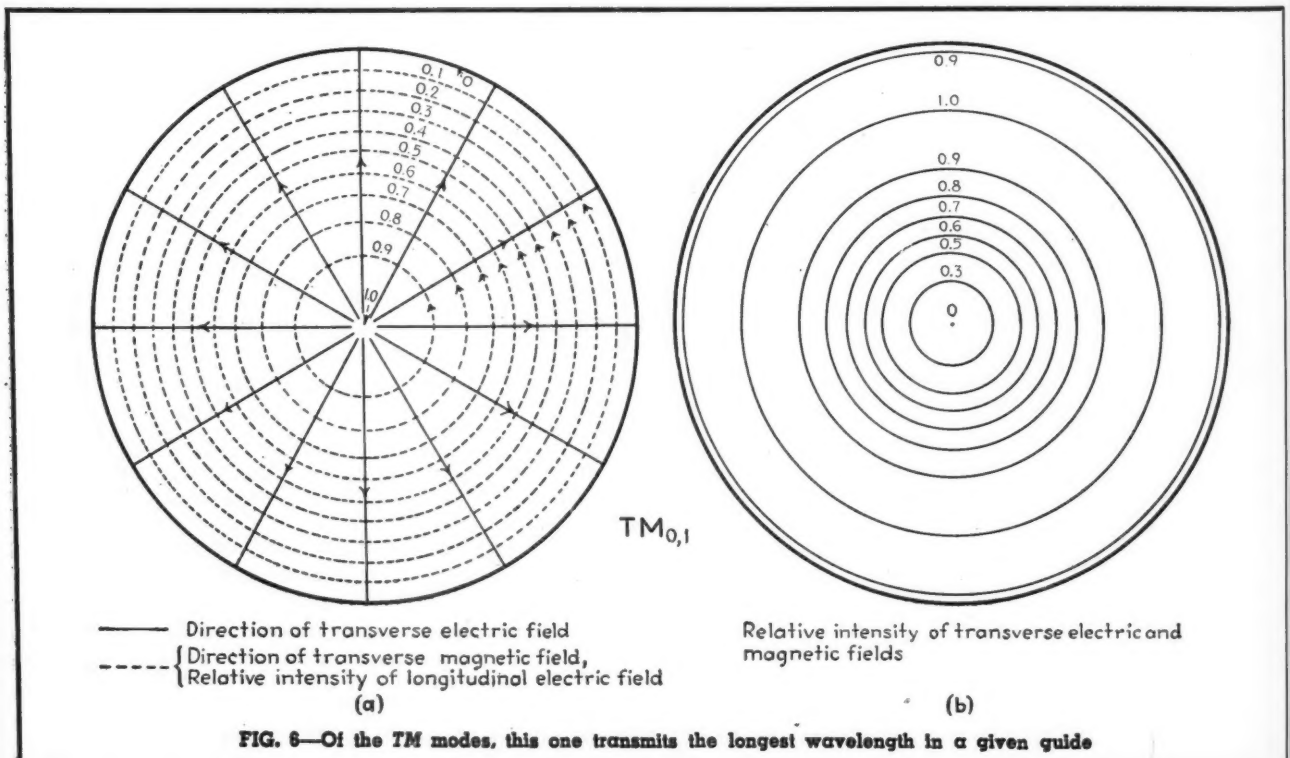


FIG. 6—Of the *TM* modes, this one transmits the longest wavelength in a given guide

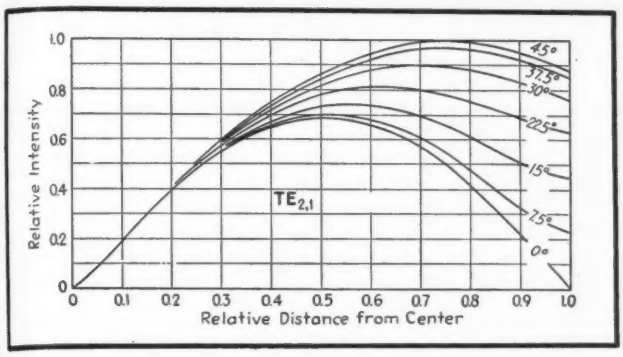


FIG. 5—This intermediate graph gives relative intensity, but not direction, of the transverse field

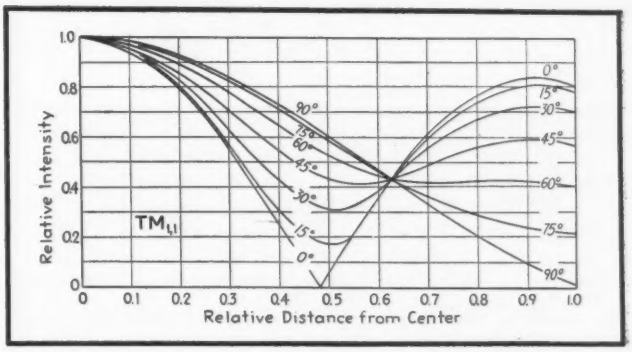


FIG. 8—Replotting these curves on polar coordinates as in Fig. 7(b) gives intensity contours

ratio between orthogonal field components. It is obviously impossible to represent the intensity or direction of the total magnetic field with a single set of curves as the longitudinal and transverse components are ninety degrees out of time phase.

TM Field Equations

The transverse magnetic waves ($TM_{n,m}$) may be represented by the following equations:

$$H_z = 0 \tag{9}$$

$$E_z = A\, J_n\,(K_m\, r/a)\, \cos\,(n\theta)\, \cos\,(\omega t - \beta x) \tag{10}$$

$$H_\theta = -\,(A/377)\,(f/f_0)\,[J_n'\,(K_m\, r/a)\, \cos\,(n\theta)\, \sin\,(\omega t - \beta x)] \tag{11}$$

$$E_r = -\,A\,\sqrt{(f/f_0)^2 - 1}\,[J_n'\,(K_m\, r/a)\, \cos\,(n\theta)\, \sin\,(\omega t - \beta x)] \tag{12}$$

$$H_r = -\,(A/377)\,(n/K_m)\,(a/r)\,(f/f_0)\,[J_n\,(K_m\, r/a)\, \sin\,(n\theta)\, \sin\,(\omega t - \beta x)] \tag{13}$$

$$E_\theta = A\,(n/K_m)\,(a/r)\,\sqrt{(f/f_0)^2 - 1}\,[J_n\,(K_m\, r/a)\, \sin\,(n\,\theta)\, \sin\,(\omega t - \beta x)] \tag{14}$$

where

K_m is the mth root of $J_n\,(K) = 0$

By a method similar to that used previously it is possible to show that the equation

$$J_n\,(K_m\, r/a)\, \cos\,(n\theta) = C \tag{15}$$

defines a family of curves which gives the direction of the transverse magnetic field and, also, contours of relative intensity for the longitudinal electric field. These curves for the $TM_{0,1}$ and $TM_{1,1}$ modes are shown by the dotted lines in Fig. 6(a) and Fig. 7(a) respectively. The directions of the transverse electric field are shown by the solid lines drawn in the same figures.

The contours of relative intensity for the transverse electric field are determined by the same general method as was used for the *TE* waves. Since no intermediate curves are needed for the $TM_{0,1}$ mode, the final result is plotted immediately in Fig. 6(b). For the $TM_{1,1}$ mode intermediate curves are necessary and these are shown in Fig. 8. The contours of relative intensity for this mode are then plotted in Fig. 7(b). As in the case of the *TE* waves, these curves apply equally well to the magnetic field.

The author gratefully acknowledges the encouragement and assistance given by Professor R. P. Siskind of the School of Electrical Engineering, Purdue University.

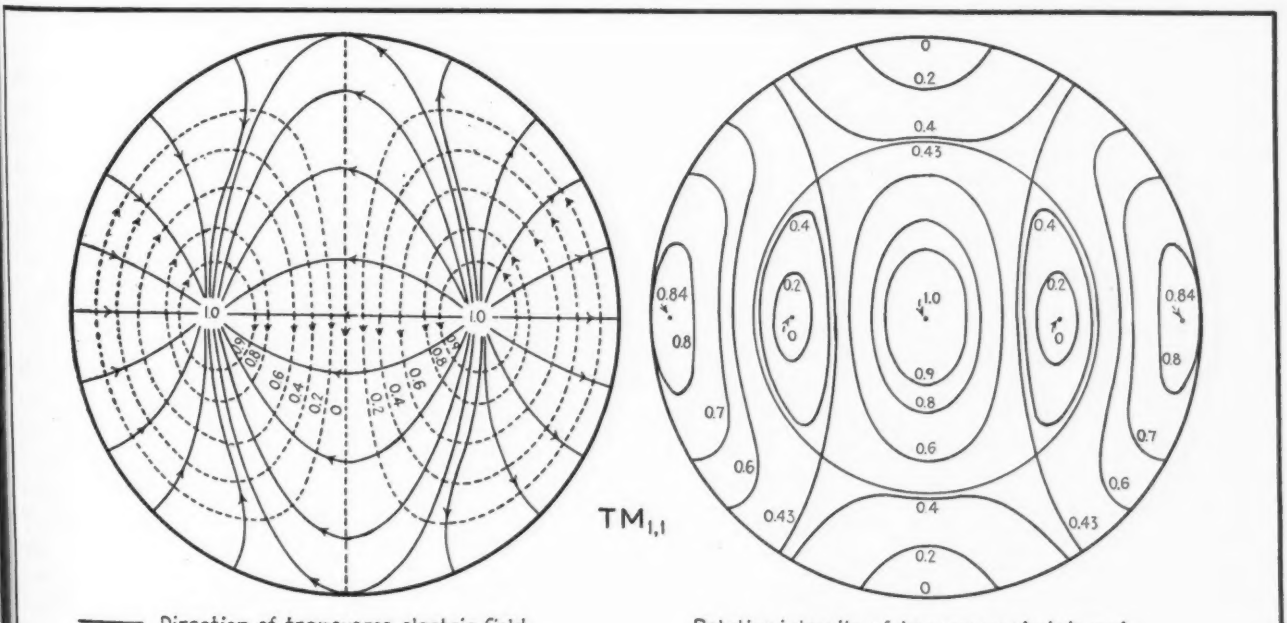
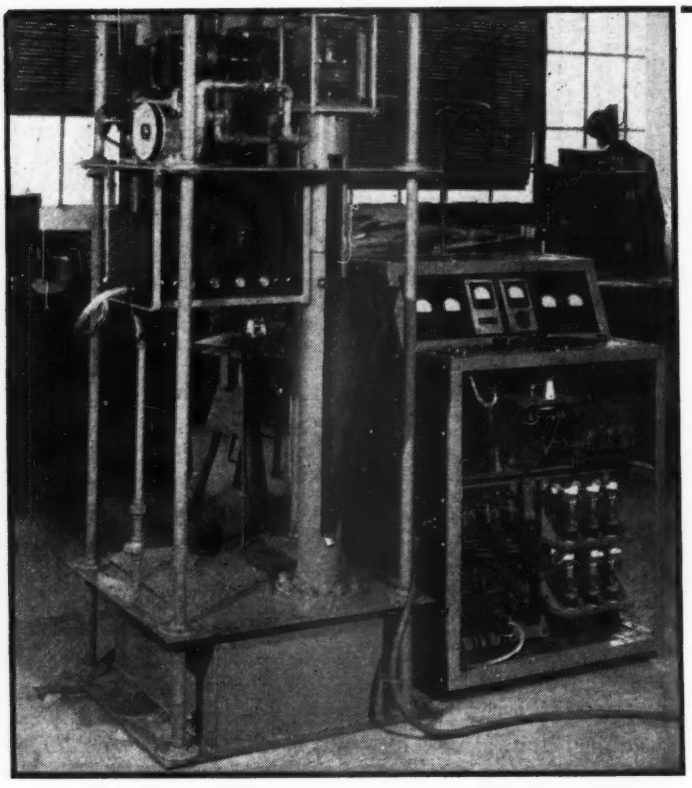


FIG. 7—This $TM_{1,1}$ mode has the same cut-off frequency as the $TE_{0,1}$ mode shown in Fig. 1

LOAD REMATCHING in



Continuous rematching equipment developed for heating a moving charge having a non-uniform cross-section, such as rifling broaches

By EUGENE MITTELMANN

Director of Electronic Research
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THE problems confronting the radio engineer designing high-frequency generators for industrial purposes are in many respects different from those encountered in the field of communications. This will perhaps be most evident when one considers the different natures of the load impedances to be dealt with in both fields.

Usually the oscillator or the final amplifier of the communications generator delivers power into a load of constant impedance. Maximum power delivery is obtained by proper matching of the load to the generator impedance.

In the field of high-frequency heating generators for industrial purposes, conditions are more complicated, due to the fact that the generator must be able to deliver power to a wide variety of load impedances, and the value of the load impedance itself in any particular application seldom remains constant; rather, it changes within wide limits during the heating cycle. The above conditions will hold true for both induction and dielectric heating.

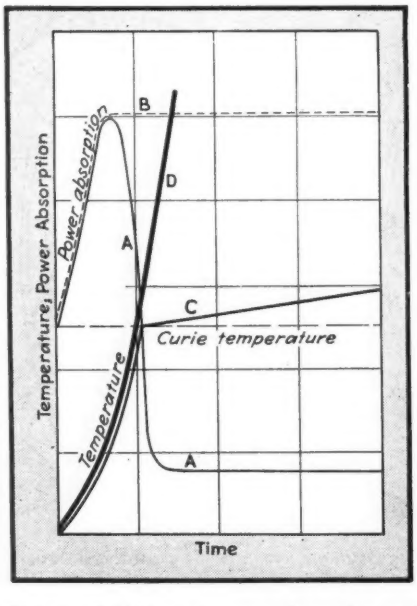


FIG. 1—Variation of power absorption and temperature of a ferromagnetic charge with time during the heating cycle, assuming constant current through heater coil

In the high-temperature heat treatment of ferrous metals by high-frequency induction, the heating cycle is divided into two distinct regions. The dividing point is around 1450 deg F, at which temperature the metal loses its magnetic properties and becomes paramagnetic. The amount of power which is absorbed by the charge and converted into heat is determined by the density of the high-frequency magnetic field. This in turn is a direct function of the magnetic permeability of the material.

In the beginning of the heating cycle the permeability, and with it the power absorption, increases and hence the temperature is raised at an accelerated rate. This corresponds to the first part of curve A in Fig. 1, which shows the power absorption for constant current through the heater coil as a function of the heating time. At the Curie point of magnetic transformation the power absorption drops rapidly below the original value at the beginning of the heating cycle, due to the loss of permeability. Correspondingly, the temperature curve C, which was rising steeply up to the critical or Curie temperature, will now increase more slowly.

The peak of curve A corresponds to the maximum value of permeability of the charge, and hence maximum power absorption. Curve B indicates the power level which it is desirable to maintain should the unit be utilized during the entire heating cycle at its full power rating. The corresponding ideal behavior of the temperature curve is represented by curve D.

From an electrical point of view the behavior of the material within the heater coil corresponds to a

From a paper presented at the National Electronics Conference, Chicago, 1944.

ELECTRONIC HEATING

Load rematching permits using peak power output for a greater portion of the heating cycle, despite permeability changes at the Curie point in induction heating and power factor changes in dielectric heating. Circuits are given for one-step rematching with relays and for continuous rematching with a thyratron-driven motor arrangement

condition where the generator feeding the heater coil first has to supply power to a low-impedance load, then to a high-impedance load after the Curie point of magnetic transformation is reached.

Somewhat similar conditions prevail in the dielectric type of high-frequency heating. For instance, in all drying processes where moisture is given up by the material during the heating cycle, both the power factor and the dielectric constant of the material decrease with heating time. The originally low-impedance load is again changed into a high-impedance load.

Contrary behavior is observed in the heat treatment of plastic materials. For most plastics the power factor increases with increasing temperature, giving increased power absorption toward the end of the heating cycle.

Advantage of Continuous Matching

In both induction and dielectric electronic heating, there is thus a certain peak load which is considerably higher than the mean value of the power averaged over the entire heating cycle. This means that the high-frequency generator cannot be set at the beginning of the heating period for full power output without running the risk of overloading the tubes at some time during the heating cycle. Furthermore, the generator must be designed for a higher peak rating than the total amount of Btu required for a certain heating job might appear to warrant.

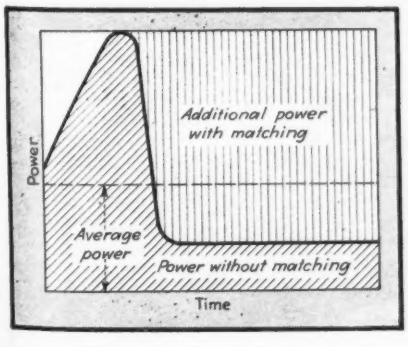


FIG. 2—Without continuous rematching of generator to load in induction heating, the total Btu of heat delivered to the charge during the heating cycle (diagonally shaded area) is only a fraction of that obtainable with the load matched at all times

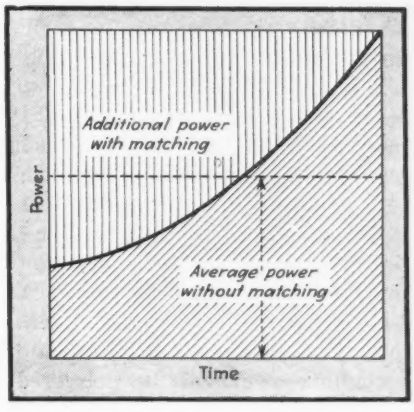


FIG. 3—In dielectric heating of thermosetting materials, power absorption increases with time because power factor increases with temperature. Continuous rematching would permit using peak power output throughout the heating cycle

Both from an engineering and an economic point of view it would, of course, be desirable to have generators available for high-frequency heating purposes which will deliver constant power to the load, irrespective of changes in impedance within reasonable limits.

In spite of the high peak power in induction heating, the average value of power absorption is relatively low, as indicated in Fig. 2. The total amount of heat energy supplied to the load is proportional to the product of time and power, and hence to the diagonally shaded area under the curve.

If conditions could be changed in such a manner as to insure continuous matching between load and generator at all times during the entire heating cycle, then the full power rating of the generator could be utilized continuously once peak power is reached. The vertically shaded area in Fig. 2 represents the additional energy that would then become available for heating.

Conditions encountered in dielectric heating of plastic materials are shown in Fig. 3. Only the diagonal shaded area of watt-seconds is available in conventional set-ups because the peak power absorption at the end of the heating cycle governs the entire cycle. However, with proper matching at the beginning of the heating cycle and continuous rematching until the end, full power could be applied at the start without running the risk of overloading the tubes toward the end.

The Problem of Rematching

In practically all applications of high-frequency heating the load impedance coupled to the generator has both reactive and resistive com-

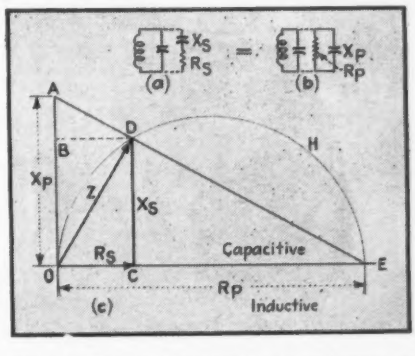


FIG. 4—Vector diagram for transformation of a series load circuit into an equivalent parallel circuit having identical power dissipation. Peak power output is delivered to the load Z as long as the loci of this vector is the circle indicated here

ponents. The load can always be represented as the series combination of a loss resistance and a reactive element, which in turn can be either inductive or capacitive.

In the load circuit of Fig. 4(a), X_s represents the total variable series reactance (the equivalent series reactance of the load plus the reactance of the variable coupling element) and R_s represents the total series resistance of the load. In the equivalent circuit of Fig. 4(b), R_P represents the equivalent parallel loss resistance and X_P the equivalent parallel reactance. The two circuits are fully equivalent if the impedance elements are related according to the impedance triangles in Fig. 4(c). When angle ODE is a right angle, triangles OCD and DCE are similar and DC/OC = CE/CD. Since CE = OE − OC = $R_P - R_s$, it follows from the laws of geometry that

$$\frac{R_P - R_s}{X_s} = \frac{X_s}{R_s} \qquad (1)$$

Triangles ABD and OCD are also similar, so that AB:OC = BD:CD, and

$$\frac{X_P - X_s}{R_s} = \frac{R_s}{X_s} \qquad (2)$$

By transformation and substitution of $|Z|^2$ for $R_s^2 + X_s^2$, the above equations become

$$R_P = |Z|^2/R_s \qquad (3)$$

$$X_P = |Z|^2/X_s \qquad (4)$$

The condition that constant power shall be absorbed by the load demands that the value of the equivalent parallel loss resistance R_P referred back to the generator terminals shall remain constant. To maintain R_P constant as the equivalent series load resistance R_s or the equivalent series reactance X_s varies, the total value of the series impedance must be so changed that the resulting impedance vector Z is one leg of a right triangle, such as ODE, of which the vector R_P is the hypotenuse and is constant in length. The circle H in Fig. 4(c), of which vector R_P is the diameter, then becomes the locus of point D. If R_P is selected to match the generator impedance, constant and maximum power will be delivered to the external load at all times.

The above principle can be used to obtain constant matching between a generator and a variable load both in induction and dielectric heating.

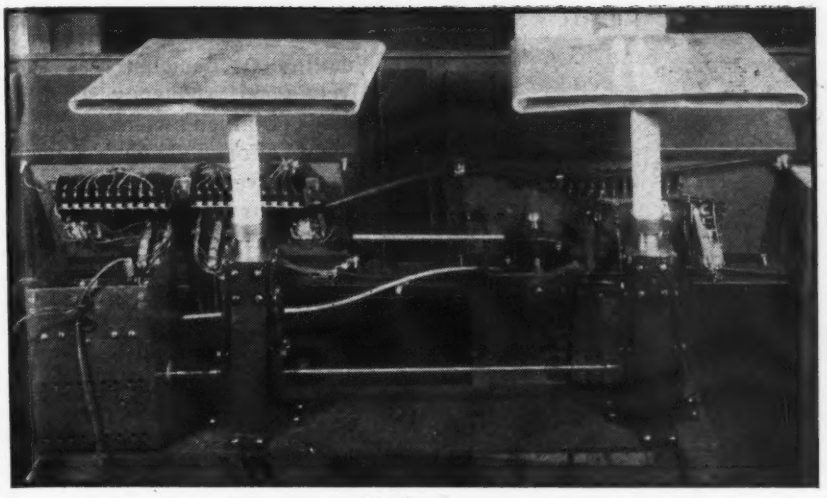
Description of Equipment

The selection of the proper rematching mechanism will necessarily be governed by the length of the heating cycle. In induction heating the cycles are usually of the order of a few seconds or even fractions of a second. In most applications of dielectric heating longer times are required, ranging from seconds up to minutes. Accordingly, two different systems of rematching will be discussed.

The circuit shown in Fig. 5 is used for rematching the generator to the changed load in high-frequency induction heating, especially in the high-temperature heat-treating of ferrous metals. The generator is of the self-excited push-pull class C type. The heater coil, with its charge, is connected to a part of the tank circuit through a double-pole, double-throw rematching relay. The heater coil forms part of an auto-transformer circuit. The tank coil center tap

Rear view of generator. Oscillator compartment, with two air-cooled transmitting tubes, is at upper left, with blower just below. Motor-driven Variac transformer for adjusting filament voltage is in approximate center of unit. Peak output of this unit is 20 kw

Electronic generator with continuous rematching equipment, developed for dielectric heating of large plastic preforms involving a load weighing from 3 to 12 pounds and varying in both power factor and dielectric constant during the heating cycle



Details of rematching mechanism for 20-kw plastic preheating unit. A thyratron-controlled motor moves the two capacitor plates towards or away from the electrodes supporting the plastic preforms

and the B+ terminal of the power supply are at ground potential.

A relay shunted by an adjustable resistance is in series with the plate power supply circuit and is so adjusted that it will respond to a predetermined peak value of the plate current. At the instant this peak value is reached, the plate circuit relay closes and preconditions an auxiliary relay, which will respond after the plate current changes by a few percent of its peak value toward lower current ratings. This corresponds to the descending part of the power absorption curve in Fig. 1. At this point a plunger-type time-delay relay applies full cut-off bias to the grids of both oscillator tubes and throws a rematching relay over to the high-impedance connection required after the Curie point. Additional contacts on the rematching relay then open the circuit of the time-delay relay, so the cut-off bias is removed after a time delay of a few milliseconds; this is just sufficient to allow the rematching relay to be actuated under no-load conditions. Holding contacts keep the rematching relay energized until a timer circuit terminates the heating cycle and resets all relay circuits for a new cycle.

The results obtained by this arrangement are remarkable for two reasons:

(1) Smaller power rating generators can be used on jobs for which far larger units were deemed necessary.

(2) High-frequency generators can be used economically for high-temperature jobs.

Figure 6 gives a performance comparison of a conventional high-frequency generator (A) and one having half the rated power output but equipped with the rematching mechanism (B). Generator A reaches the critical temperature of magnetic transformation somewhat sooner, but after the Curie temperature is passed the smaller unit delivers heat to the charge at a higher rate and thus arrives at higher temperatures in a shorter time.

The temperature rise before the Curie point is closely approximated by a square-law function, and for this reason the time difference between the two points at which Curie temperature is reached is relatively small. The higher the required temperatures, the greater are the differences in efficiency and required heating time.

Surface hardening of ¾-inch diameter steel rings to various depths has been achieved in 3.5 seconds with a 2-Mc generator of only 2.5 kw output, by using a rematching unit. This is interesting because up to now it was not considered possible to obtain case hardening with power inputs less than about 10 kw per square inch. The heating time for surface hardening to ⅛-inch depth was 3 seconds. The temperature of magnetic transformation was reached within the first 2 seconds. During the change-over

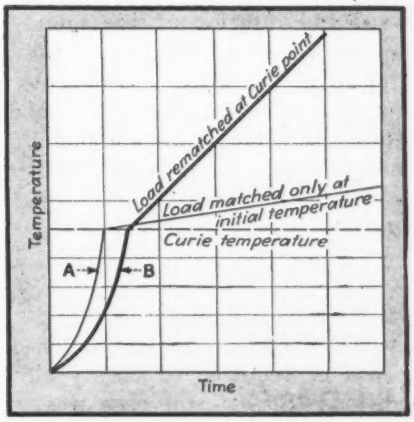


FIG. 6—Time-temperature curves for two high-frequency generators used for induction heating. The smaller unit with rematching (B) reaches temperatures above the Curie point much faster than generator A which has twice the output rating of B

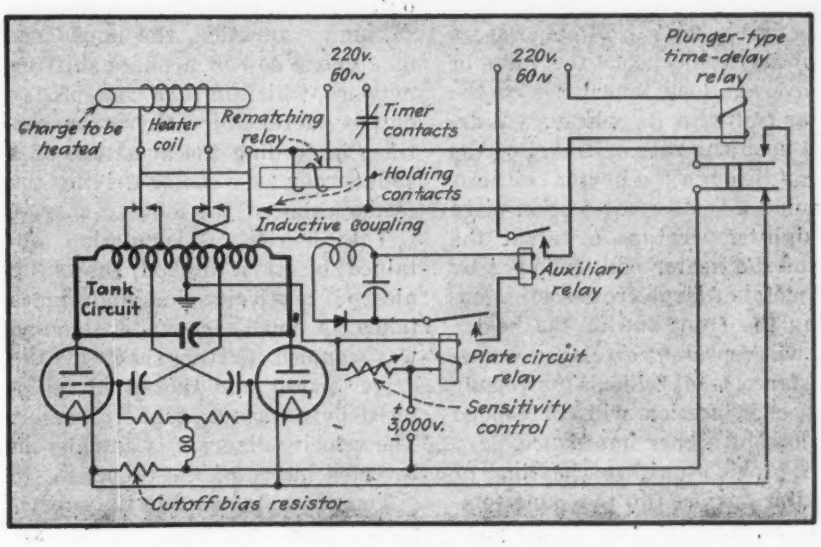
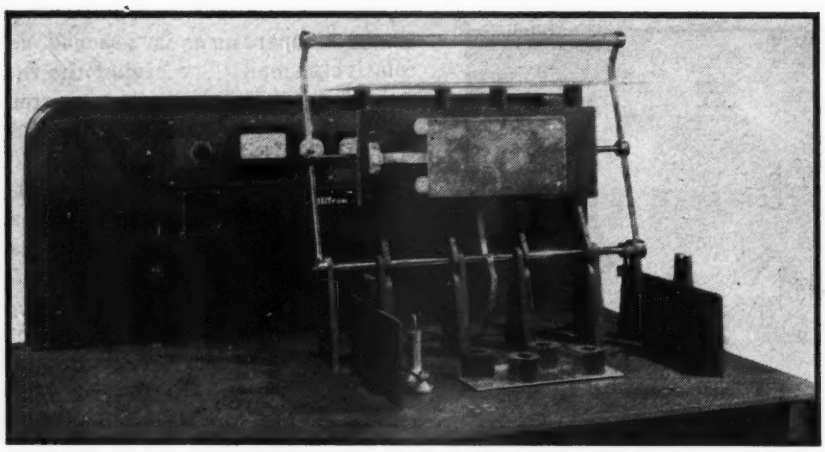


FIG. 5—Simplified schematic diagram of induction heating unit providing one step automatic rematching of tank circuit to load. The timer contacts open momentarily at the end of the heating cycle to release the rematching relay in preparation for a new cycle



Details of working table of 5-kw unit, with four preforms in position and top electrode raised

time, a few milliseconds, a certain equalization of the temperature gradient existing from the surface toward the interior of the metal takes place. As a result, when full power is applied again to the sample a lower thermal flow will exist toward the interior of the metal. Consequently, surface hardening is obtained with relatively low high-frequency power input.

Continuous Rematching

In a number of instances of induction heating, continuous matching will be required to satisfy all conditions. Such is the case when dealing with a charge fed continuously through the heater coil but of variable cross-section. An example is shown in Fig. 7, involving high-frequency heat treatment of a rifling broach.

The relative distribution of high-temperature and low-temperature metal mass, and hence the value of the average load impedance of the heater coil with its charge, will depend upon the rate of travel of the charge through the heater coil. For instance, a small cross-section piece of high-temperature metal at the end of the heater coil, followed by cold metal of large cross-section entering the front end of the heater coil, will represent a relatively low-impedance load, while a uniformly small cross-section will correspond to a load of higher impedance.

To provide uniform heating of all outer surfaces to the same temperature, the heater coil is designed to match the load to the generator at an average mass of metal within the heater coil traveling at an average speed. Every deviation from these predetermined averages will correspond to a change in load impedance and will be accordingly reflected back into the plate circuit of the oscillator.

A schematic diagram of the equipment is also shown in Fig. 7. Variation of oscillator plate current from a predetermined optimum value is used to provide a system of continuous rematching. A variable control rheostat in series with the plate current circuit converts the plate current variations into voltage variations and drives the input of a bridge-type amplifier having one control and one compensating tube. The bias of the compensating tube is so set that for the desired plate current of the oscillator a certain output current is obtained from the amplifier. This output current is used to change, through saturation, the impedance of a choke coil in a phase-shifting network, which in turn controls the output current of a thyratron rectifier in feeding the armature of a shunt-wound d-c motor driving the feeder cable of the moving charge.

The degree of regulation obtained by this method shows up nicely if a velocity-time diagram is taken. A small tachometer dynamo was coupled to the shaft of the driver motor and the speed registered by a vacuum-tube voltmeter. The velocity diagram is actually an inverted image of the broach.

The generator used in the experiment, shown elsewhere in this article along with its associated quenching device, pumps, etc., was a 2-megacycle, 2.5-kw unit. The entire 64-inch broach was heated to 2350 deg F in 92 seconds. Incidentally, this equipment demonstrates that relatively good frequency stability could be obtained without much additional effort. The frequency variation between no-load and full-load conditions at any instant was not over 75 kc total band width.

Rematching in Plastic Heating

The problem of heating plastic preforms demands equipment where the continuous adjustment of matching can be obtained between load and generator to secure maximum power absorption by the load during the entire heating cycle.

The solution is perhaps best illustrated by describing a commercially built equipment of 20-kw high-frequency output, used in the preheating of large plastic preforms. The load may vary between three to twelve pounds weight, and it was demanded that the generator shall adjust itself automatically to any new load conditions without any necessity for the operator to make adjustments.

The electronic generator used in this arrangement is of the self-excited push-pull type, with the center of the tank circuit grounded and connected to the positive terminal of the high-voltage power supply as shown in Fig. 8. The load is placed between two capacitor plates, which in turn are coupled to the tank circut by means of a variable capacitance. The spacing between the capacitor plates containing the load and the coupling plate can be changed by a reversible motor.

The feedback and initial coupling are so adjusted that for the rated maximum plate current of the oscillator tubes, matching is obtained and maximum power is delivered to the load. Any variation of the load impedance will be reflected into the plate circuit. The changing voltage drop across variable resistor R, due to plate current variations, drives the balanced-tube bridge amplifier. Two relays are connected across the output of the balanced bridge, each in series with a rectifier which allows current to pass through only one of the relays for either unbalanced condition. Thus, for increasing load impedance one of the relays will re-

spond, closing contacts 1 of the reversible 220-volt, 60-cps motor; this moves the coupling reactance in a direction increasing the spacing, thus increasing the coupling reactance between load and generator to correct the matching. For a decrease in load, relay 2 will respond, closing contacts and reversing the motor so as to move the coupling plates in the opposite direction.

Operation During Heating Cycle

During the heating cycle of plastic preforms, the power factor of the material increases with increasing temperature. The coupling at the beginning, being adjusted for maximum power absorption, matches a relatively high-impedance load. In the course of the heating cycle the power factor will increase and the load impedance decrease accordingly. The balanced amplifier will try to correct for the lower impedance and therefore the control motor will adjust the coupling in the direction of a larger coupling reactance by increasing the spacing between the coupling plate and the electrodes. This means that at the end of the completed heating cycle both coupling plates will be in a position of maximum distance from the electrodes, and hence provide minimum coupling between load and generator. The next cycle will start at this minimum-coupling position, excluding the possibility of an overloaded plate circuit. Once the next cycle is started the rematching mechanism will automatically seek its own position of optimum coupling, corresponding to matched conditions between load and generator.

After the filament voltage is brought up to its nominal value the unit is made ready to operate by pushing a starter button on the front panel. This turns on the high-voltage power supply and simultaneously connects the armature of the reversible rematching motor across the 60-cycle, 220-volt line.

A high-frequency wattmeter indicates the amount of high-frequency power converted into heat within the load. The load electrodes are accessible after opening the screen gate in front of the unit, which automatically shuts off the high-voltage circuit. Proper recycling is obtained by a timer circuit.

The fact that the generator automatically adjusts itself to maximum power output at any present level makes it possible that a number of molding presses calling for various amounts of preform material can be supplied alternately without making any changes on the generator or its associated circuits. Such operations were performed successfully by unskilled labor.

A 5-kw generator using the same principles of automatic rematching was developed primarily for multi-cavity molding. The preforms are placed on the bottom electrode. The top electrode, which can be lifted by a lever mechanism, will adjust itself to any spacing corresponding to the thickness of the preform. Correspondingly, the matching capacitors will seek automatically their position of maximum power output. Power is applied to the high-voltage circuits of the d-c plate supply only when the top electrode reaches its final position, and power is disconnected when the top electrode is lifted. A timer circuit starts and ends the period during which power is applied.

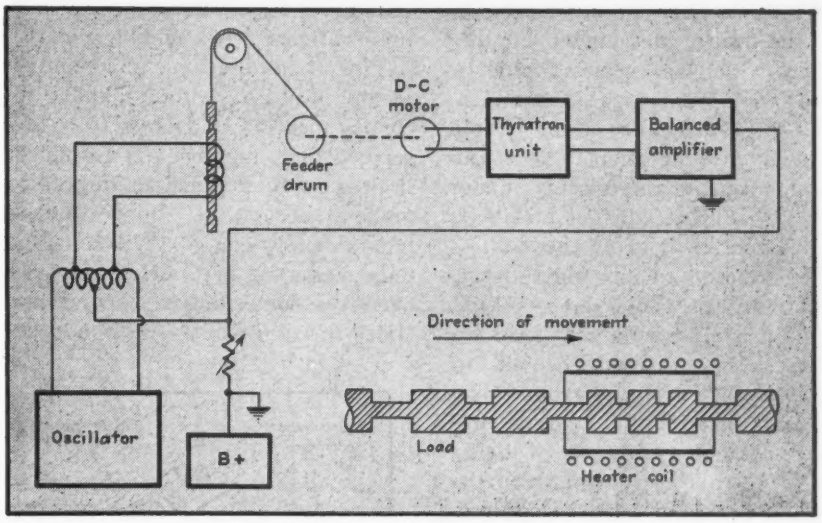


FIG. 7—Schematic diagram of electronic heating unit provided with continuous rematching equipment for heating to a constant surface temperature a moving charge of non-uniform cross-section as shown at the lower right

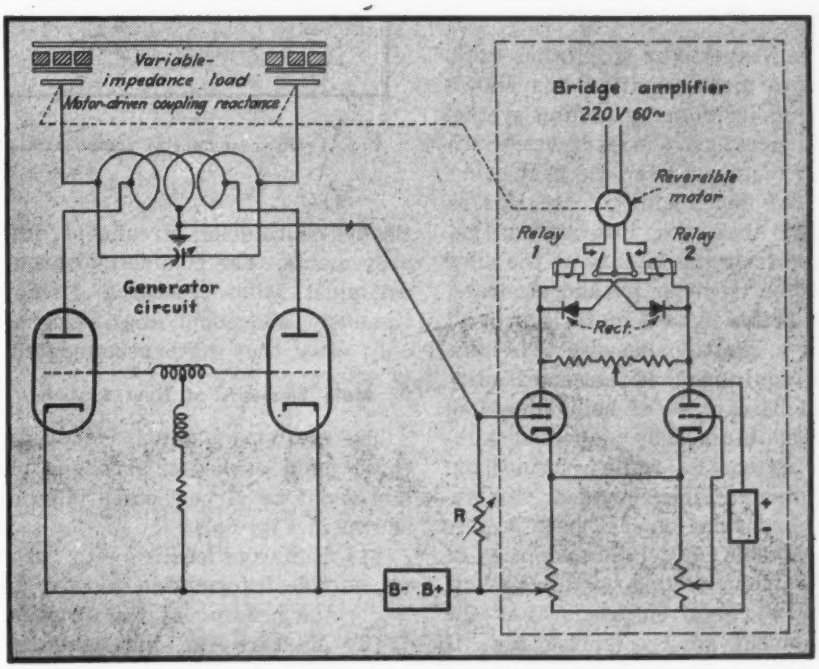


FIG. 8—Simplified schematic diagram of dielectric heating generator provided with automatic and continuous readjustment of matching between the load and the generator tank circuit

The CAA Instrument Landing System . . .

First complete technical details of blind landing system officially adopted for civil aviation in U. S. Installation program is under way and will be accelerated after the war. Part I covers theoretical aspects and runway localizer circuits

THE following is a description of the radio instrument landing system which has been adopted by the Civil Aeronautics Administration for use throughout the United States by civil aviation. The installation program is already under way, although it will not attain its full volume until after the war.

The function of any ideal instrument landing system is to permit the pilot of an airplane to land his craft safely without benefit of visual contact with the ground during any part of the landing procedure. The advantages of being able to do this are obvious and the problem has long been recognized. Many and varied solutions have been proposed but all are based on the use of radio in some form.

Basic Requirements

Long experience with other radio aids to air navigation has shown that an instrument landing system for general use should meet certain basic requirements—the first being that of dependability. By this is meant that the information received from the facility by the pilot must be trustworthy and accurate. It is better to have no facility at all than a questionable one. The second requirement is that the facility shall be capable of being operated and maintained by personnel without extensive radio engineering training. Failure to meet this requirement has, in fact, been largely responsible for delay in adoption of instrument landing by this agency. Another requirement is that the equipment shall comprise few, if any, parts not easily available or manufacturable. The fourth, and by no means the least important, is that the system shall impose a minimum of new work on the pilot.

This combination of requirements is quite stringent and difficult to meet. The system to be described does not meet it fully, yet it does so to a sufficient degree to make it acceptable. Improvements have already been, and will continue to be made. As in all fields, research produces sometimes a slow, sometimes a rapid—but always a practically continuous stream of improvements. The commercial product must follow research discontinuously, and adopt improvements only after they have accumulated.

Main Elements of New System

The system adopted comprises three main elements, arranged on and about an airport essentially as shown in Fig. 1:

(1) Runway localizer—to provide information relative to the heading of the aircraft.
(2) Markers—to indicate distance from point of contact.
(3) Glide path localizer—to provide indication of altitude.

The first of these radiates signals which overlap and produce an equi-signal zone (or course) aligned with the axis of the runway. A zero-center differential indicating instrument in the cockpit will indicate zero as long as the airplane is in this zone, and will have deflections to the right or left as the craft departs from on-course. The runway localizer operates in the frequency band from 108 Mc to 111 Mc.

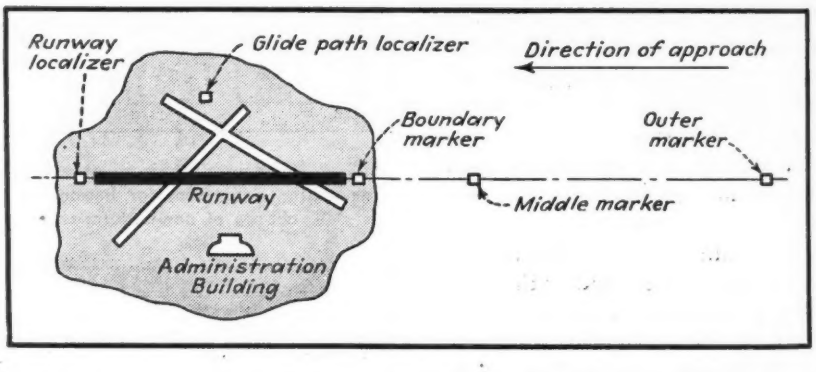


FIG. 1—Arrangement of components of CAA instrument landing system on and near a typical airport

The second element comprises two (sometimes three) low-powered transmitters located at specified distances from the point of contact, along the extended axis of the runway, and radiating sharply vertical patterns. Each of these transmitters operates a different colored light in the airplane to permit the pilot to identify the marker being received. All markers operate at 75 Mc.

Equi-Signal Glide Path

The third element has only recently been developed to a satisfactory stage and is not yet being installed. It will therefore not be de-

. . . Part I

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Chief, Radio Engineering Section
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scribed in this paper, except by stating that it, too, radiates two overlapping signals to produce an equi-signal zone or on-course. The equi-signal surface is a vertical circular cone with the apex on the antenna. The station is located to one side of the runway so that the vertical plane through the localizer course cuts the cone parallel to but not through the axis. The intersection of the plane and the cone is thus a hyperbola. If the pilot were to follow both the glide path course and the localizer course, he would actually be traveling along a portion of this hyperbola. His position in space would thus be absolutely determined at all times during his descent, and by properly controlling the position and shape of the hyperbola, the aircraft could be brought to a complete landing without necessity of seeing the ground. Actually, the radiated patterns can be modified so that the surface of intersection is not exactly a right circular cone, but is such as to result in a more or less straight line glide path. It is anticipated that this equipment will operate at a frequency in the vicinity of 300 Mc.

An equi-signal glide path of this type was experimentally set up by Messrs. D. M. Stuart and J. C. Hromada at the Indianapolis Experimental Station of the CAA in 1938. The results were completely successful and tests, including flight tests, showed the system to be a practical one. For a number of reasons, not all technical, it was necessary to abandon this project, and constant-intensity glide path was then evolved which required the aircraft to follow a path of constant signal intensity. While the

Checking adjustment of loop antenna system for runway localizer of newly-adopted CAA radio instrument landing system

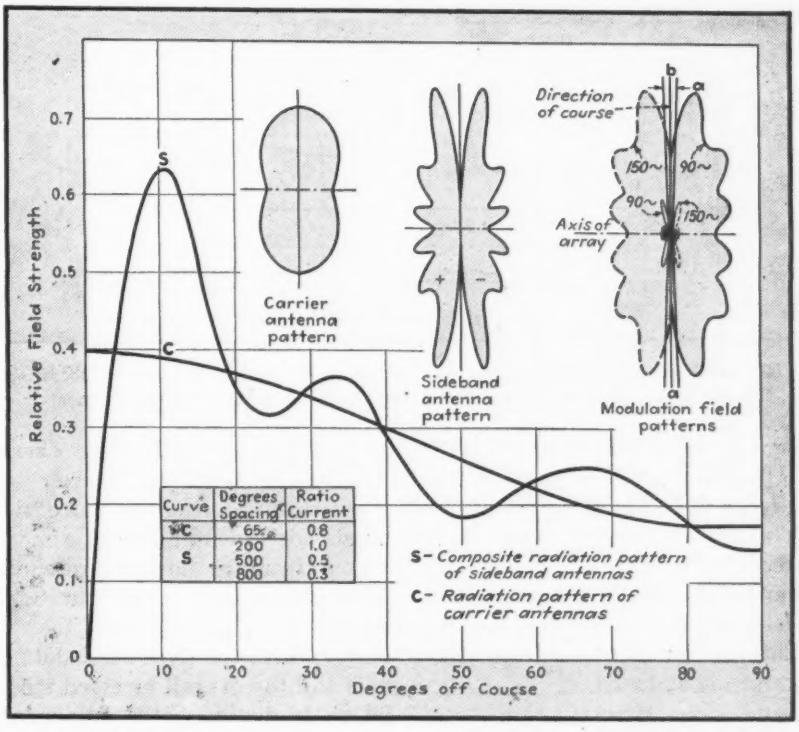


FIG. 2—Radiation patterns of the sideband and carrier antennas, plotted in both rectangular and polar coordinates

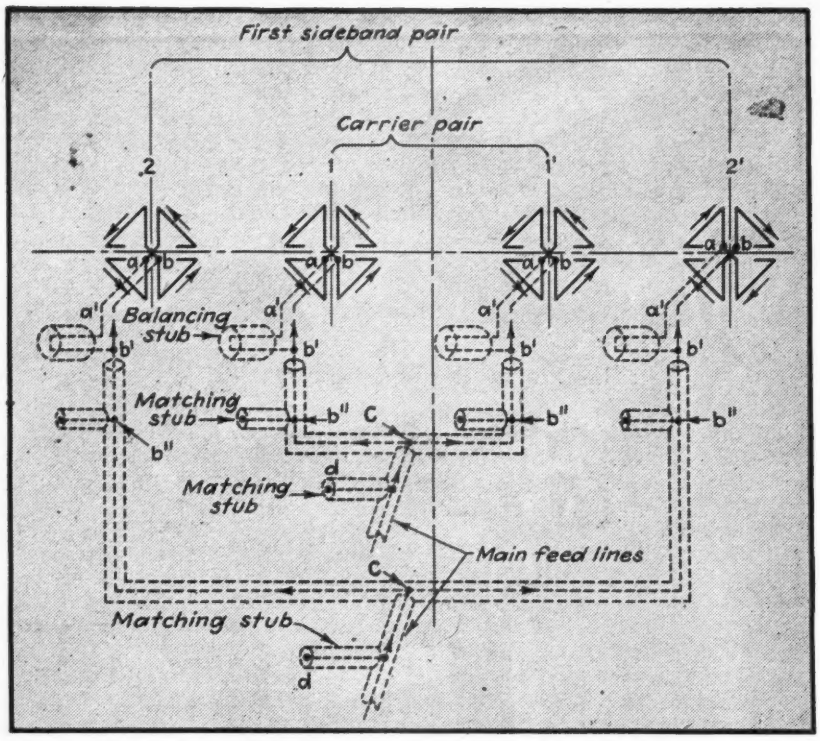


FIG. 3—Schematic diagram showing general arrangement of the first two pairs of antenna circuits associated with the runway localizer

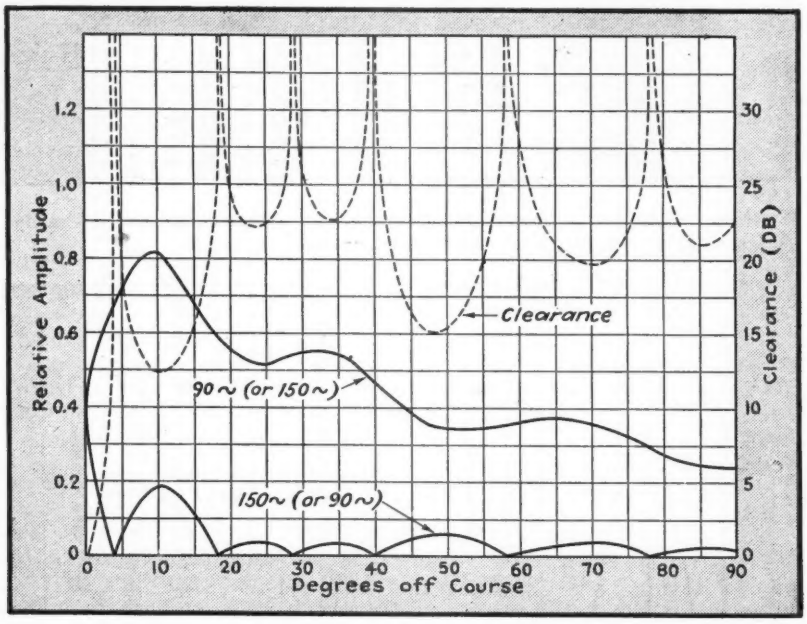


FIG. 4—Composite sideband pattern due to all radiators of runway localizer (solid lines) and variation of clearance with azimuth (dash-dash lines)

scheme is technically feasible, it is not practical because the actual glide path depends on too many factors which are likely to vary, such as receiver sensitivity, transmitter power output, etc. This became very evident after one or two trial installations and the scheme was therefore abandoned.

Theory of Runway Localizer

The localizer radiates two types of signals—a modulated carrier (from the so-called carrier antenna) and a group of pure sidebands corresponding to this modulation (from the sideband antenna). The sidebands from the first signal effectively combine (in the receiver) with the pure sideband signals and the overall received modulation is due to both components. The space pattern of the modulation can be controlled by means of both antennas, and this is done so as to produce two different patterns for the 90-cps and 150-cps modulation frequencies.

The radiation patterns are made highly directive, with the maximum approximately ten degrees from the course as shown in Fig. 2. The purpose of this is to maintain as much signal near the course as possible and at the same time minimize the off-course signal that might reach buildings or other structures and be reflected therefrom. Such reflections often are strong enough to affect the patterns and cause so-called multiple-course indications, and course-bends. The pattern of the carrier (about 110 Mc) is in fact much less directional, as it should be, since it is desired that the ave in the aircraft receiver be operative regardless of bearing with respect to the transmitter.

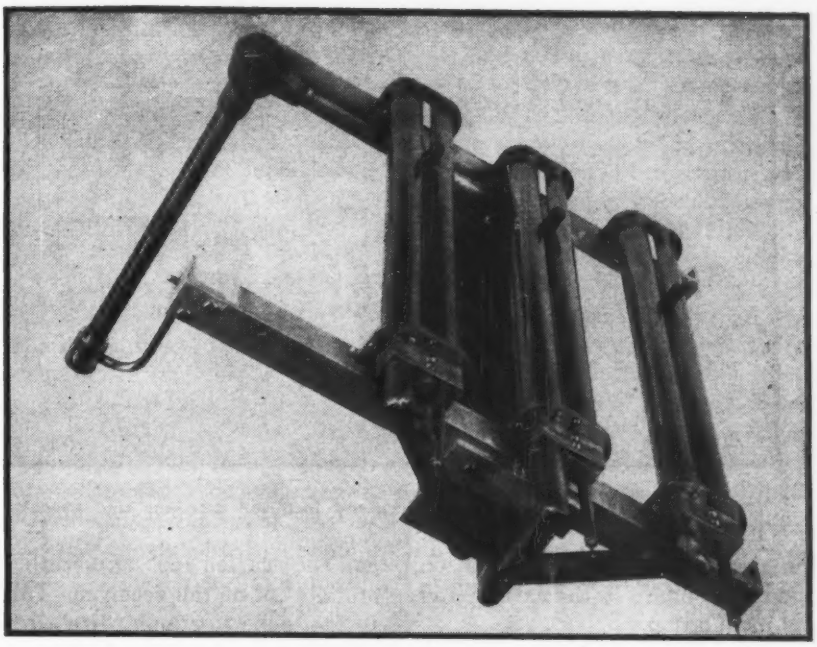
To obtain the desired radiation pattern, a linear array of radiators is arranged with the axis perpendicular to, and the center on the axis of the runway. The array is arranged in pairs, each symmetrical about the center. The radiators are vertical magnetic doublets (horizontal current loops) with patterns circular in the horizontal plane. The center pair, henceforth called carrier pair, is operated in phase with each other and fed with normally modulated carrier. The resulting radiation then contains the carrier frequency and all of the associated sidebands. Each of these sidebands will, of course, have the same space pattern as the carrier (due to the negligible difference in frequency between carrier pairs and sideband pairs).

As is well known, the electric field resulting from such a doublet has no components except in a plane at right angles to the axis of the doublet. In this case, the field is therefore purely horizontal which is of some practical advantage. For example, vertical metallic supports, lines, conduits, etc., inevitable in an actual installation, do not absorb any energy and therefore do not observably distort the radiated pattern. Furthermore, the coefficient of reflection from large surfaces is slightly less for horizontally polarized waves—particularly if the angle of incidence approaches the value of Brewster's angle (which

in this case is of the order of 6.5°). On the other hand, a number of comparative tests of vertical as well as horizontal arrays has failed to demonstrate unequivocally the superiority of one or the other type of polarization. In view of this and of the definite advantages of vertical arrays in simplicity and economy, the latter have not been summarily dismissed from future consideration.

The elements of each of the other pairs (hereafter called sideband pairs) are operated 180 degrees out of phase and all elements on one side of the center are in phase with each other. All the sideband pairs are, furthermore, fed in quadrature with the carrier pair. Feed arrangements for the carrier pair and the first sideband pair are shown in Fig. 3.

Since a further rotation of 90 degrees is inherent in the radiation from the sideband pairs (see Appendix I), the resultant pattern will be in phase (or 180 degrees out of phase) with that radiated by the carrier pair. The pattern for three sideband pairs (the usual number in a typical installation) is shown in Fig. 2. There are only two lobes, of opposite phase, and with nulls along the direction of the course. It is to be noted that the phase in the pattern is independent of azimuth except for the two reversals at the nulls.



Quarter-wave transmission line transformers used as phasing controls to place all sideband antenna pairs in phase with each other and in quadrature with the carrier antenna pair of the runway localizer system

The pattern from the carrier pair is likewise of constant phase. The resultant pattern due to a combination of the two therefore is merely the algebraic sum. With the proper choice of current ratios, the resultant can be placed almost wholly on one side of the course line with little or no radiation on the other side, and the side of maximum radiation is that in which the sideband lobe is in phase with the pattern from the carrier pair. To produce the modulation field patterns of Fig. 2, the right-hand sideband lobe is arranged to be in phase with the carrier pattern in

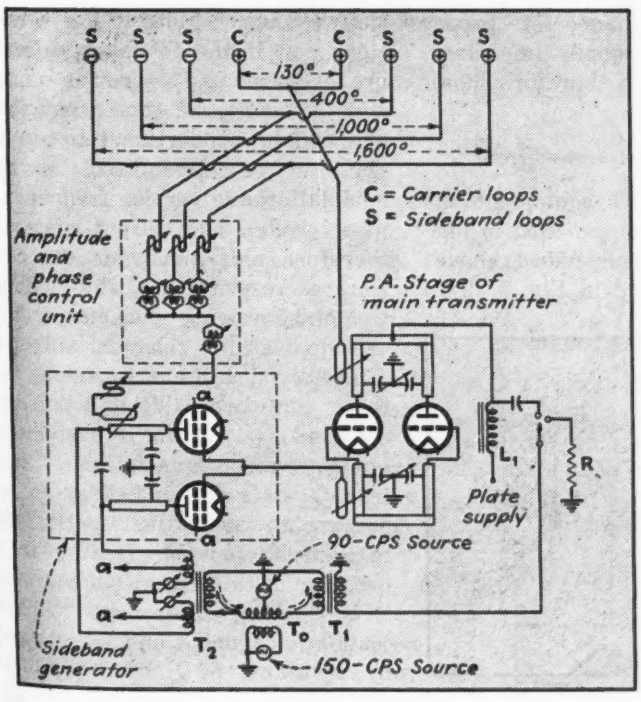


FIG. 5—Output and antenna circuits of runway localizer. Main transmitter feeds only carrier loop, with other loops being fed by the sideband generator

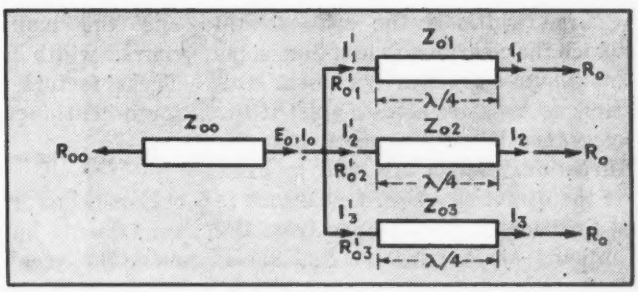


FIG. 6 (above)—Phase control unit serving the antenna system

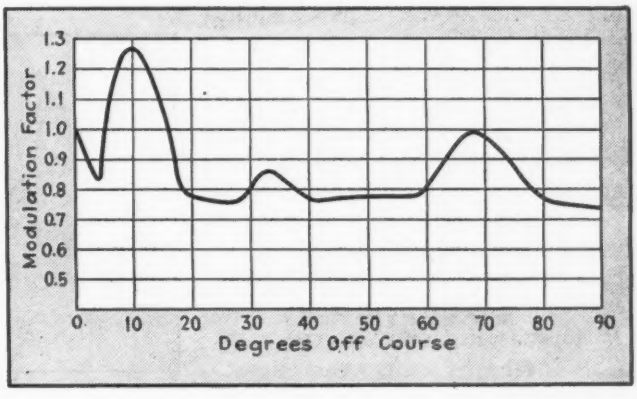
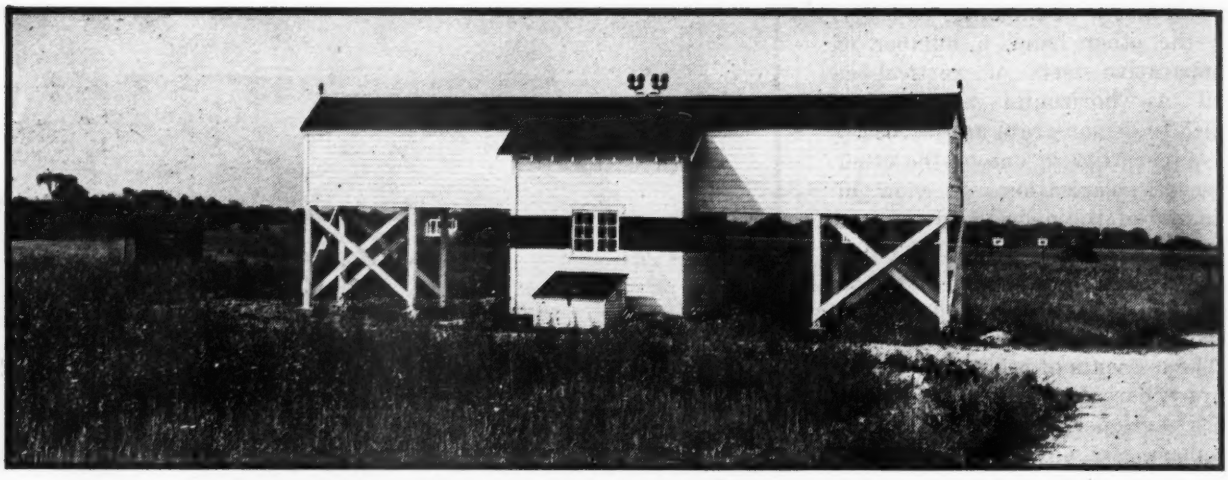


FIG. 7—Variation of modulation factor of runway localizer



Building housing runway localizer antennas and associated transmitter equipment

the case of the 90-cps modulation, and out of phase in the case of 150-cps modulation.

Course Clearance and Sharpness

There are several characteristics of these patterns which are important in the operation of the localizer. Figure 4 represents, in rectangular coordinates, one quadrant of the modulation field patterns shown in polar form in Fig. 2. The ratio of amplitudes of the two modulation frequencies in any direction (in decibels) is defined as clearance. The clearance in a direction 1½ degrees off course is defined as r-f course sharpness. Along the course, the clearance is obviously zero. Course width is the zone within which the clearance is less than some maximum—arbitrarily chosen. Multiple courses are said to exist if the clearance is zero in more than one direction. Bends are said to exist if the direction of zero clearance is a function of the distance from the antenna array.

Another form of course sharpness depends on the receiving equipment as well as the radiated pattern. This may be termed a-f sharpness and it is that which is observed by the pilot on his indicating instrument. This is a differential instrument with deflections proportional to the differences of the two modulation voltages: $D = K\ (C_{90} - C_{150})$, where K is a function of the instrument itself. It is evident that D depends not only on the ratio C_{90}/C_{150} (the r-f course sharpness), but also on the absolute values of these voltages, so that the deflection for a given value of C_{90}/C_{150} can be varied by adjusting the audio gain of the receiver. This is in fact done to standardize aircraft equipment.

The discussion is devoted mainly to clearance since this is a characteristic of the transmitting system only, and not of the receiving system also, as a-f sharpness is. (Actually, the observed clearance is also a function of the surrounding terrain.)

In operation, it is important that the clearance in all directions (except on course) be adequate so as to produce no multiples nor even the impression that a course is being approached. The importance of proper course alignment is obvious and the maintenance of proper course width is equally important. These factors are therefore monitored continuously.

Description of Transmitter

Somewhat novel equipment arrangements have been used to produce the results described above; these are indicated in Fig. 5. Two main sources of r-f power feed the antenna array, one supplying modulated carrier to the carrier pair of loops (c) and one supplying pure sideband energy to the sideband pairs (s).

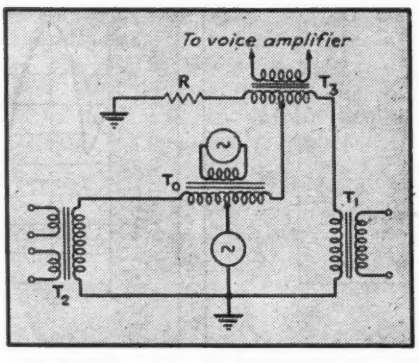


FIG. 8—Hybrid unit used with voice channel to give verbal instructions to incoming pilots over runway localizer radio system

Modulated carrier power is obtained from the output tank of a 200-watt transmitter and carried directly to the antenna by means of 70-ohm coaxial line. The transmitter is crystal-controlled and the power amplifier stage is plate-modulated by the 90-cps and 150-cps signals from the motor-alternator unit. Pure carrier from the grid circuit of this amplifier is used to excite a sideband generator, the plate circuit of which is fed by the modulation voltage. Under these conditions and if the tubes and circuit are balanced and operating under class C conditions, the output voltage will be proportional to $\sin qt \sin \omega t$ where $q/2\pi$ and $\omega/2\pi$ are the modulation and carrier frequencies respectively. This output contains, therefore, only sidebands (no carrier) corresponding to the modulation and carrier frequencies, and is used to feed the sideband antenna.

The division of energy among the three (or more) sideband pairs is achieved by the fixed system of quarter-wave transmission line transformers shown in Fig. 6, requiring no field adjustments. This is a most desirable feature in a program of this magnitude in which it is frequently necessary to have installations made and maintained by personnel of limited technical qualifications. The loads (R_0) are all equal to each other and are essentially 70 ohms resistive.

The desired current ratio is $I_1:I_2:I_3 = 1:0.5:0.3$, hence the desired power ratio is $P_1:P_2:P_3 = 1:0.25:0.09$. The power input to each transformer section being E_0^2/R_0', it follows that $(1/R_{0'1}):(1/R_{0'2}):(1/R_{0'3}) = 1:0.25:0.09$, and since $Z_{01}^2 = R_0R_{0'1}$, etc., the characteristic admittances have the same relative values as the currents. The impedance Z_{00} is selected to match the parallel impedances of the three sections to the source R_{00}. The value of Z_{01} is chosen to result in practical dimensions for the various conductors and for this reason is different from R_0.

Audio Hybrid Circuit

The phasing, which determines on which side of the course the main lobe of each modulation pattern occurs, is accomplished in a special audio hybrid circuit. Referring to Fig. 5, the 90-cps source and the 150-cps source are connected into a balanced center-tapped transformer. The center-tapped winding is loaded symmetrically by the sideband generator plate circuit and the main transmitter p.a. plate circuit. Under these conditions, the 90-cps components in these loads are in phase with each other, and the 150-cps components are out of phase.

This same relationship (or the reverse, depending on the polarities of the coupling transformers) persists up to and including the antenna array, thus producing modulation field patterns similar to that in Fig. 2. In order that these phase relationships be obtained, it is necessary that the loads presented by the two coupling transformers, T_1 and T_2, be purely resistive and equal. If they are not purely resistive, it is likely that they will not have the same phase angle and usually their reactance will differ for the two modulation frequencies. This disturbs the desired phase relations and results in interaction between the two audio-frequency sources by virtue of the unbalance in transformer T_0.

In the actual equipment, the phase angles of the loads presented by T_1 and T_2 are of the order of two or three degrees. The value of this phase angle is affected chiefly by the self inductances of the various transformer windings (and the inductor L_1), which are several hundred henrys or more (although, due to the magnitudes involved, the leakage reactance may become important without the necessary precautions)*.

Modulation Percentage

The 200-watt carrier is modulated 100 percent on course, assuming no voice channel; with voice on the same carrier, the 90 and 150-cps modulation would be correspondingly less. With peak modulation by both 90 cps and 150 cps, each of these frequencies modulates the carrier only 50 percent. A useful modulating power of 25 watts at each frequency is, therefore, required. With a plate efficiency of the order of 50 percent in the p.a., the actual power required is more nearly 50 watts, and considering further that a like amount is required by the sideband generator (actually somewhat more due to the lower efficiency of the latter), it can be seen that each modulation generator must furnish about 100 watts.

With 100 percent modulation on course (where the contribution from the side-band loops is zero), the modulation off course will in general differ from 100 percent and will vary with azimuth due to the radiation pattern of the array. It might offhand appear that if the carrier is itself modulated 100 percent, the superposition of radiation from the sideband loops would result in overmodulation everywhere except on course. This is not the case. Radiation from the sideband loops adds to the carrier modulation for one of the modulation frequencies, but subtracts for the other, so that the net result can be, and for most values of azimuth is less than 100 percent modulation (see Fig. 7). It is evident that overmodulation does not occur except between 5 deg and 15 deg off-course, and the maximum is only 128 percent.

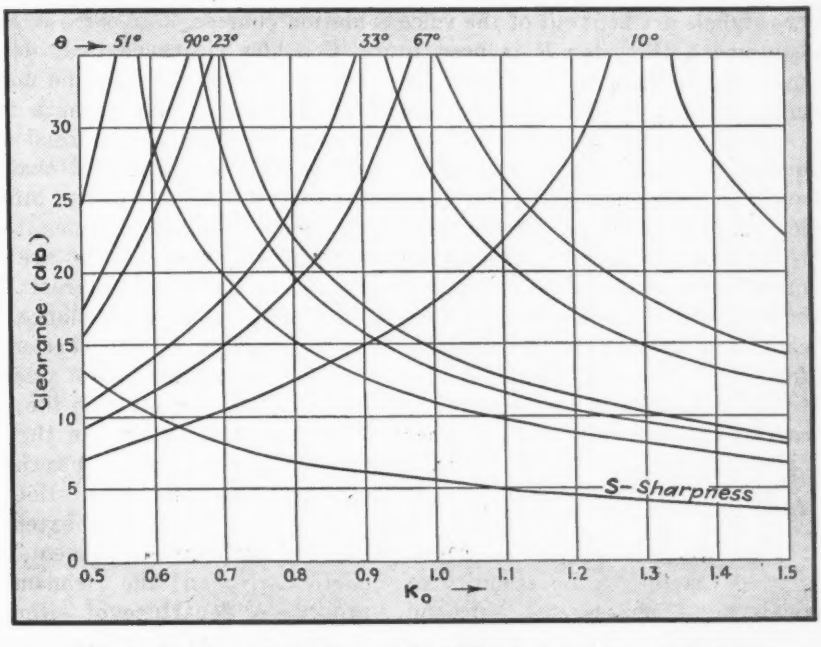


FIG. 9—Variation of clearance with sideband current in carrier loops

Insertion of Voice Channel

It is sometimes desirable to be able to operate a voice channel on the localizer to permit phone contacts with a pilot prior to or during an actual approach. This is easily done, the insertion of the voice modulation being made in the hybrid circuit consisting of transformers T_0, T_1 and T_2 (Fig. 5). Voice signals are introduced by a third

*It is easy to show that if the secondary of a transformer is loaded by a resistive load R, and if the self-reactance of the secondary winding is $X = kR$, then the impedance looking into the primary will have a phase angle equal to $\tan^{-1}(1/k)$, assuming no leakage reactance. For this angle to be three degrees for $R = 10{,}000$ ohms, X must be at least 190,000 ohms, which requires the self-inductance (at 90 cps) to be 340 henrys. On the other hand, such large inductances introduce the problem of leakage reactance. If the reflected impedance is of the order of 1,000 ohms, then the leakage reactance cannot exceed about 50 ohms (or roughly 0.1 henry).

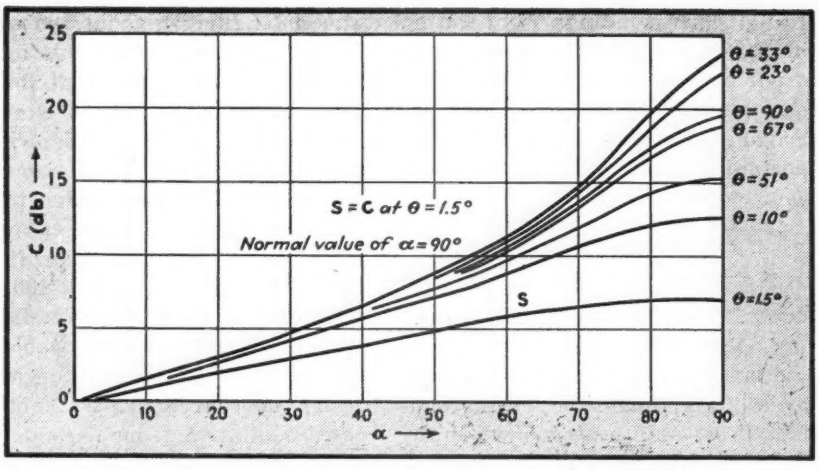


FIG. 10—Variation of clearance with phase of carrier loop current

transformer (T_3 in Fig. 8) also having a center-tapped secondary forming a second balanced circuit. In this manner, the 90-cps and 150-cps signals are kept out of the voice equipment. Resistor R is used to maintain balance on T_3. The voice channel in both transmitting and receiving equipment has a low-frequency limit of about 200 cps to avoid interference with the basic localizer frequencies. When voice is used, the localizer frequencies are made to produce a peak modulation of the order of 60 percent to 70 percent, the balance being available for voice. It should be noted that voice modulation is radiated by the carrier antenna only, and the space pattern will be that of the latter.

Stability Considerations

Since the stability of the system depends partly on the stability of relative r-f phases, the sideband generator is driven, as stated, directly from the unmodulated grid tank of the transmitter power amplifier. All r-f energy is carried over coaxial copper lines with air dielectric, and the lines to the antenna array are filled with dry air under low pressure to prevent breathing of moisture. An experimental installation utilizing solid-dielectric cables throughout has been made. If satisfactory, these cables would evidently be preferable to air dielectric lines.

The system is inherently quite stable for any reasonable variation in the several parameters. The alignment of the course is not affected by any change except one which in some way modifies the symmetry of the patterns about the direction of the course. This might result from mechanical injury to one side of the array, or to a failure of one only of the two modulation sources.

Consider clearance C as defined above. Figure 4 shows the normal variation of C with azimuth for a typical installation in normal operation. It will be noticed that for certain directions C is infinite, whereas for other directions it goes through minima. There are two factors of principal interest from the standpoint of maintenance. One is the phasing of the carrier antenna with respect to the sideband antenna, and the other is the ratio k_0 of sideband current in the carrier antenna as compared to that in the first sideband pair. Both of these depend to a large extent on the transmitting equipment, and particularly on the transmitter proper. A departure of either of these factors (but not both) from normal will affect the values of minimum clearance, but not the position of these minima relative to the course (see Appendix I).

Figure 9 shows the variation of minimum clearance values with variation of k_0 for $\alpha = \pi/2$, and Fig. 10 shows the corresponding variation with α for the normal value of k_0. (The curves marked S represent course sharpness. or clearance at $\theta = 1.52$.) A departure of either α or k_0 from normal reduces the value of one or more of the clearance minima, yet a change in k_0 by 40 percent or a change in α of 45 degrees results in clearances not smaller than 6 db. Both of these minima are adequate for proper operation provided the aircraft receiver has sufficient audio gain. Figure 11 shows corresponding effects for changes in the current of the third (outermost) sideband pair.

A pertinent question commonly raised concerns the effect of unbalance in the sideband generator, resulting for example from the failure of one of the tubes. The most evident effect is to introduce carrier into the sideband loops, and the consequent radiation will merely distort somewhat the overall carrier space pattern. Another effect is to reduce the sideband output, which amounts to increasing the value of k_0 in Fig. 9. However, even if one of the tubes fails completely, this effectively increases k_0 by a factor of about 2; Fig. 9 shows the relatively small effect of this on clearance and sharpness. There is no need for using matched tubes.

To insure the maximum possible stability of the system, the equipment is itself designed to be stable within very close tolerances over a wide range of ambient and service conditions, as is done with all equipment used in CAA facilities.

Monitoring the Runway Localizer

The above study of the operational changes to be expected when different parameters vary has pointed the way to the method of monitoring the localizer. The question of monitoring the localizer (as well as the other parts of the system) is naturally important since the equipment is unattended in all installations.

The first and obvious concern is with the proper alignment of the course. In the first installations a field detector was placed 150 feet from the antenna, directly on either the front or back course. The position of the course is, however, relatively stable and independent of some of the more likely malfunctionings of equipment such as detuning of transmitter p.a. or sideband generator. On the other hand, such variables do affect the clearance off course, and a receiver located on course would not reveal these changes.

It is important to have ample clearance off-course to avoid serious confusion to a pilot. A receiver is therefore located about 50 de-

grees off course to permit monitoring this clearance, the one on course being used to monitor course alignment and signal level. The signal from the clearance monitor is fed through a transmission line (Fig. 12) to the control tower where it operates a visual indicator as well as alarm and recording circuits. The course monitor is arranged so that if the course moved beyond a predetermined limit, or if the level changes more than a preset amount, its output operates to open the line carrying the clearance signal and thereby causes various alarm and other circuits to function at the control tower. Lines from the marker stations carry corresponding signals which also operate the recorder and alarm functions as well as visual indicators. Since these signals are all at different audio frequencies they are easily separated, where necessary, by appropriate filters.

Tune-Up Procedure

The system has been designed with consideration for the limited technical training of installation and maintenance personnel. One feature which contributes materially to simplifying the tune-up process is the possibility of radiating simultaneously unmodulated carrier from the carrier pair and sidebands from the sideband pairs. This can be done as shown in Fig. 5 by loading the modulation transformer in the transmitter with a dummy load in lieu of the p.a. plate circuit. The only modulation on the carrier is then that due to radiation from the sideband loops. The latter can be phased correctly by adjusting the phaser to each sideband pair until the audio signal on the output of the clearance monitor is a maximum (see Appendix I). This process is a matter of a few minutes. In earlier systems making use of mechanical modulation it was impossible to radiate pure carrier simultaneously with pure sidebands, and the phasing process involved lengthy field observations of patterns, requiring from a few days to a few weeks.

Likewise, the ratio of sideband current in the carrier loops, to the sideband current in the sideband loops (the quantity k_0) is readily adjusted by comparing (by field measurements at one position) the modulation due to radiation from the sideband loops with the modulation from the transmitter. The latter reading is obtained with no radiation from the sideband loops.

The remainder of this two-part article, to appear in the next issue, describes the runway localizer equipment in considerable detail and takes up the various topographical factors affecting the location of the equipment at an airport.

APPENDIX I

For the array used, and if the loop currents are $k_n \cos \omega t$, the space pattern for the sidebands of one modulation frequency is given by

$$p = K (p_1^2 + p_2^2)^{1/2} \cos (\omega t + \psi) \quad (1)$$

where

$p_1 \equiv k_0 \cos \alpha \cos \beta_0$

$p_2 \equiv k_0 \sin \alpha \cos \beta_0 + a$

$a \equiv \sin \beta_1 + k_2 \sin \beta_2 + k_3 \sin \beta_3$

$\beta_0 \equiv \delta_0 \sin \theta$, $\beta_1 \equiv \delta_1 \sin \theta$, etc.

$\delta_0, \delta_1, \ldots \equiv$ electrical spacing of loops from center of array

$\theta \equiv$ azimuth measured from perpendicular bisector of array.

$k_0, k_2, \ldots \equiv$ relative amplitudes of radiator currents referred to the current in the first sideband pair.

$\psi \equiv \tan^{-1} (p_2/p_1)$

$\alpha \equiv$ phase of carrier loops relative to sideband loops.

It follows from Eq. (1) that the radiation from the sideband loops is in quadrature with the loop currents. This may be seen by eliminating the terms due to the carrier pair (i.e., $p_1 = 0$, $p_2 = a$). This im-

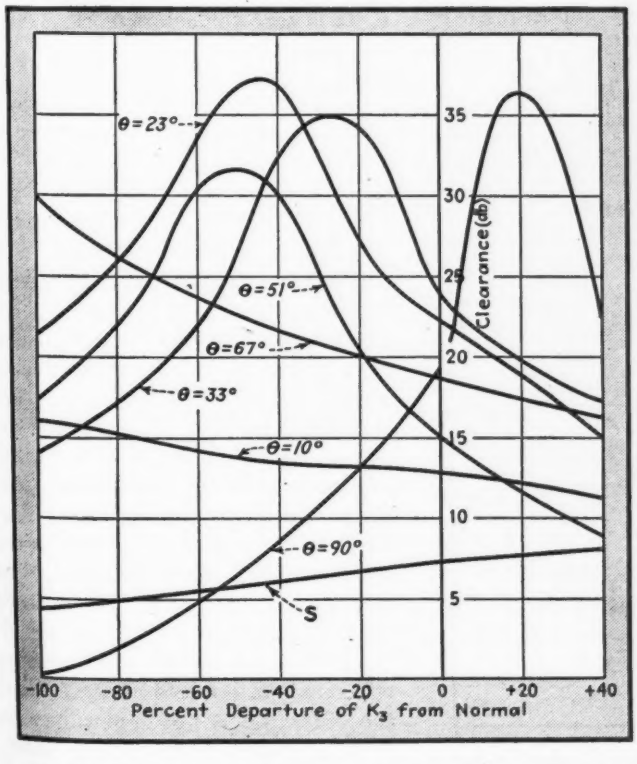


FIG. 11—Variation of clearance with current in outer pair

Localizer field monitor used to detect failure of on-course pattern

mediately results in $\psi = \tan^{-1}\infty = \pi/2$. On the other hand, the radiation from the carrier pair is in phase with the loop current since if $a = 0$, then ψ is equal to α, the original phase of the carrier loop currents. For optimum addition of radiation from these two portions of the array the sideband loops must be fed in quadrature with respect to the carrier loops, i.e., $\alpha = \pi/2$. This optimum phasing may also be deduced by considering the magnitude of p from Eq. (1). This may be written $|p| = K(k_0^2 \cos^2 \beta_0 + a^2 + 2ak_0 \sin \alpha \cos \beta_0)^{\frac{1}{2}}$ which is obviously maximum when $\alpha = \pi/2$ (a, k_0 and $\cos \beta_0$ being positive).

In any direction θ, the sideband signal due to one modulation frequency will be as given above by Eq. (1), while that due to the other modulation frequency will be

$$p' = K(p_1^2 + p_2^2)^{\frac{1}{2}} \cos(\omega t + \psi') \quad (3)$$

where

$$p_2 \equiv k_0 \sin \alpha \cos \beta_0 - a$$

and

$$\psi' \equiv \tan^{-1}(p_2/p_1) \quad (4)$$

The clearance, as defined previously, will then be

$$C = 20 \log (p/p') \quad (5)$$

and the sharpness S will be the value of C at $\theta = 1.5°$. On course ($\theta = 0$), $p = p'$ and $C = 0$. As θ departs from 0, C increases rapidly and should, preferably, remain as large as possible. Actually, it increases and decreases for different values of θ, and there will be some direction, or directions, in which it will have a minimum value (not less than 10 db, however). If, for any reason, the values of k or α vary, this minimum value of C will vary also, though not the positions at which the minima occur. This may be seen by considering the ratio p/p' on which C depends:

$$R \equiv (p/p')^2 = \frac{k_0^2 \cos^2 \beta_0 + a^2 + 2ak_0 \sin \alpha \cos \beta_0}{k_0^2 \cos^2 \beta_0 + a^2 - 2ak_0 \sin \alpha \cos \beta_0} \quad (6)$$

Without further manipulation, it is evident from Eq. (6) that for any value of θ, R approaches unity (and hence the clearance C approaches zero) as α departs from the value $\pi/2$. At the extreme value $\alpha = 0$, the clearance is zero in all directions. Evidently, also, if $C > 0$ for $\alpha = \pi/2$, it will remain greater than zero for all values of α except $\alpha = 0$.

It may also be seen from Eq. (6) that the values of θ where C has minima remain unchanged though the values of the minima decrease as α departs from $\pi/2$. By rewriting R as

$$R = \frac{g^2 + 2g \sin \alpha + 1}{g^2 - 2g \sin \alpha + 1} \quad (7)$$

it follows that

$$\frac{\partial R}{\partial \theta} = \frac{4 \sin \alpha (1 - 2g^2)}{(g^2 - 2g \sin \alpha + 1)^2} \frac{\partial g}{\partial \theta} \quad (8)$$

The values of θ where C has minima (or maxima) are determined by $\partial C/\partial \theta = 0$; from Eq. (5), (7) and (9) this reduces to $(1 - 2g^2)\partial g/\partial \theta = 0$, which is independent of α.

It is likewise easy to show from Eq. (6) that the positions (but not the values) of minima for C are independent of k_0 provided $\alpha = \pi/2$. This is not true for other values of α. Figure 9 shows the variation of the values of these minima with k_0, for $\alpha = \pi/2$. Figure 10 shows the variation of these same minima with α, for $k_0 = 0.8$ (its normal value).

In considering Fig. 9 and 10, it should be remembered that they refer to the clearance C as defined by Eq. (5). This clearance so defined depends only on the ratio p/p' and these are merely the amplitudes of the resultant radiated sidebands. The modulation factors at the two audio frequencies do not necessarily have this same ratio except for $\alpha = \pi/2$, in which case the sidebands are in the proper phase with respect to the carrier for all values of θ. When $\alpha \neq \pi/2$ this is no longer the case.

For $\alpha = \pi/2$, the radiated carrier and sidebands are

$$\cos qt + m \cos pt \cos qt \quad (9)$$

When $\alpha \neq \pi/2$, the sidebands are no longer in phase with the carrier, so to speak, and the expression may be written

$$\cos(qt + \psi) + m(\theta) \cos pt \cos qt \quad (10)$$

where ψ is the phase shift due to α. It is zero for $\alpha = \pi/2$. Equation (10) reduces to

$$(1 + 2m \cos \psi \cos pt + m^2 \cos^2 pt)^{\frac{1}{2}} \cos(qt + \psi)$$

The effective modulation factor is thus

$$m' = (1 + 2m \cos \psi + m^2)^{\frac{1}{2}} - 1 \quad (11)$$

The variation in m' with ψ is slow if ψ is not excessive, and for $\psi =$ 45 degrees the effective modulation factor is only 17 percent below maximum. Now the change in ψ is always less than the departure of α from $\pi/2$. This is due to the fact that α affects only the sideband energy radiated by the sideband loops, that radiated by the center pair always being in proper phase. Furthermore, changes in α reduce the effective modulation due to p' as well as that due to p. From these considerations, it follows that variations in α of less than 45 degrees will result in reduced clearance, but the reduction is not generally such as to produce points of zero clearance, or apparent spurious courses.

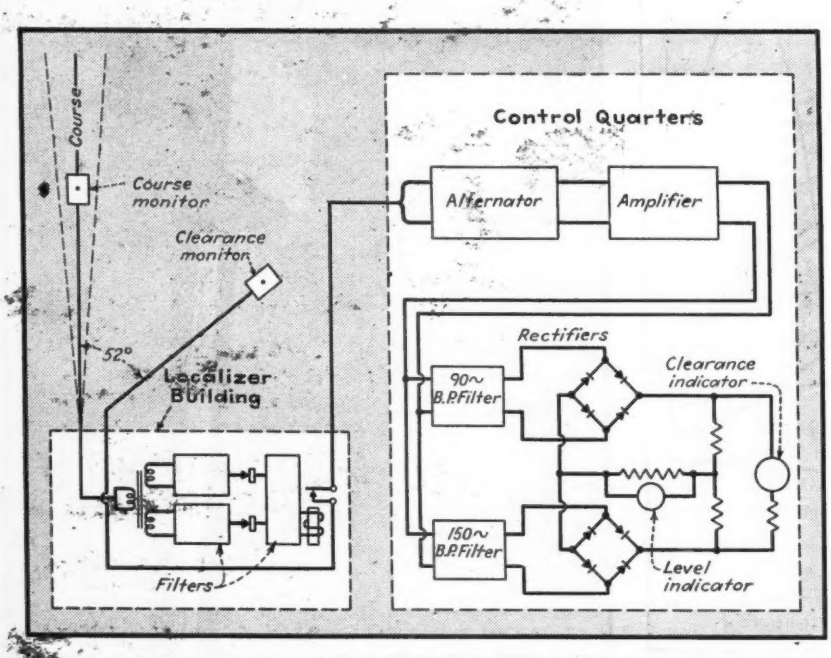


FIG. 12—General arrangement of monitoring equipment with respect to the runway localizer field

Tubeless Probe for VTVM

R-F circuit loading due to the input admittance of the measuring instrument is reduced by employing a cathode follower in the input circuit of a vacuum-tube voltmeter

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USERS of vacuum-tube voltmeters who have struggled with necessarily bulky vacuum-tube probes in confined spaces will appreciate the value of the arrangement to be described. The circuit is practically as effective as a vacuum-tube probe and has the advantage of permitting the tube to be located some distance away from the circuit under test.

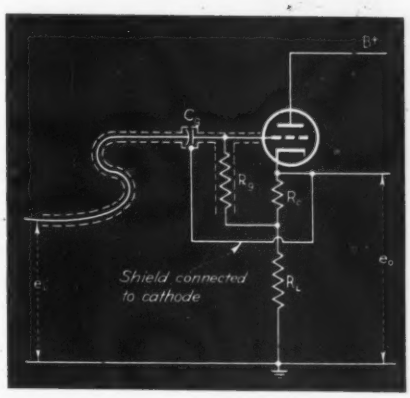
A cathode follower is employed, and is fed through a shielded conductor. The shield is not grounded but is connected directly to the cathode of the tube. The capacitance of the shielded conductor thus is added to the grid-cathode capacitance of the cathode follower, but because of the cathode-follower characteristics this total capacitance does not appear as such at the input terminals. The effective input capacitance at the probe terminals is the total capacitance between grid and cathode multiplied by a reduction factor which by proper design may be 0.01.

Circuit Theory

The chief characteristics of the cathode follower are low input capacitance, high input resistance, and low output impedance. These are given as $C_i = \alpha\, C_g$, $R_i = R_g/\alpha$, $Z_o = A/G_m$ where C_g = total effective capacitance between grid and cathode of the tube, R_g = effective grid-cathode resistance, A = gain of the circuit, and $\alpha = 1 - A = \frac{e_i - e_o}{e_i}$, a number less than unity.

An analysis of the circuit will show that the gain

$$A = e_o/e_i = \frac{1}{1 + 1/\mu + 1/G_m Z_L}$$



Cathode-follower circuit for use in vtvm to eliminate the tube in the test probe

and the reduction factor $\alpha = 1 - A = 1/\mu + 1/G_m Z_L$ approximately, if μ and $G_m Z_L$ are large. Large values of μ and G_m thus are desirable in order that α may be small.

The output impedance of the cathode follower is its cathode-to-ground impedance, and its value from the equivalent circuit is A/G_m, assuming the source impedance to be small as compared with the actual grid-cathode impedance. This also is the impedance of the shield to ground. The larger the G_m, therefore, the smaller is this value. Although the shield is not directly grounded, its impedance to ground nevertheless will be low. The effective input resistance, at the probe terminals, is the actual grid-cathode resistance multiplied by the reduction factor $1/\alpha$.

Operating Values

A circuit of this type, which the writer has found useful at frequencies up to several hundred kilocycles, employs a type 6SF5 high-mu triode operating under the conditions: E_b = 100 v; I_b = 0.4 ma; E_g = −1v.

With circuit constants as follows: E_b = 200 v; C_g = 1000 $\mu\mu$f; R_g = 10 megohms; R_s = 2500 ohms; R_L = 250,000 ohms.

The published values of μ and G_m for these conditions are respectively 100, and 1150 micromhos, giving a value of α = 0.013. Hence the two-foot length of 60-$\mu\mu$f-per-foot shielded cable used as an input lead should appear as a shunt capacitance of only $2 \times 60 \times 0.013 = 1.6$ $\mu\mu$f. With total grid-cathode resistance of 5 megohms, the apparent shunt input resistance is 5/0.013 = 380 megohms.

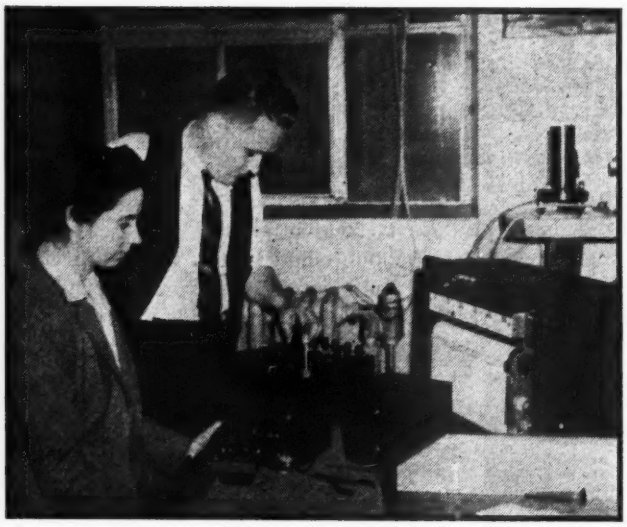
The measured input impedance of this circuit was found to be approximately 5 $\mu\mu$f in parallel with 300 megohms at frequencies from 1 cps to 500,000 cps, the difference between 5 $\mu\mu$f and 1.6 $\mu\mu$f being accounted for as the grid-to-ground capacitance within the tube. The voltage gain is about 0.98.

Limitations

The chief limitation of the high frequency operation of this circuit is the cathode-ground capacitance, since this must be considered as shunting the cathode resistor for the purpose of evaluating Z_L. The high frequency limit evidently may be extended by using a tube having a higher transconductance and requiring a lower value of cathode resistor. The low frequency limit may be extended by increasing the value of C_g.

The cathode-to-ground impedance of the tube appears relatively low even for a source impedance as high as several megohms, and hum pickup is much reduced as compared with an unshielded lead. For low-level measurements, a double-shielded cable may be used, the inner shield being connected to the cathode and the outer one to ground. With the double shield, the cutoff value will be constant and independent of location but it will be lower because of the increased cathode-to-ground capacitance.

A Photoelectric



Calibrating the phototube amplifier

Optical system of sensitive galvanometer operates amplifier which has sufficient output to operate a recording meter. Feedback from amplifier to galvanometer eliminates necessity for damping resistor and reduces galvanometer deflection by mechanical vibration

By GABRIELLE ASSET

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TO MEASURE voltages as low as one microvolt a phototube amplifier has been developed for use with a sensitive galvanometer and an electronic recorder. The galvanometer deflection acts optically on a twin phototube to produce an unbalance which is amplified so that it is measurable by means of the recorder. A feedback circuit to the galvanometer reduces the effect of vibration. Under good conditions readings on the one-microvolt range can be duplicated within ±0.75 percent.

As an example of the application of this instrument, in the petroleum and rubber industries infrared radiant energy is used for spectroscopic analysis of hydrocarbons. In the majority of such analytical equipment, transmitted radiation falls upon a thermocouple or thermopile setting up an electromotive force of the order of 10 microvolts or less.

Measuring such a small emf under industrial conditions requires a detecting device which is sensitive yet sturdy. The recorder used with the detecting device should also be sturdy and have a wide, easily read scale which is linear with the thermocouple emf. A sufficiently sensitive detecting device cannot directly operate a reliably sturdy recorder.

Galvanometer and Recorder

The galvanometer with which the amplifier is designed to be used is a Leeds and Northrup type 2500 which has a sensitivity of 0.32 microvolts per mm at one meter, a coil resistance of 11.5 ohms and a period of 5 seconds. Although the critical damping resistance is 52 ohms, none was necessary because of the damping of negative feedback from the amplifier. This galvanometer represents a compromise between sensitivity and ease of adjustment. A more sensitive galvanometer can be used to greater advantage in some instances, employing a larger negative feedback for the microvolt scale for the same galvanometer deflection. However, more time is required for the adjustment of the more sensitive instrument.

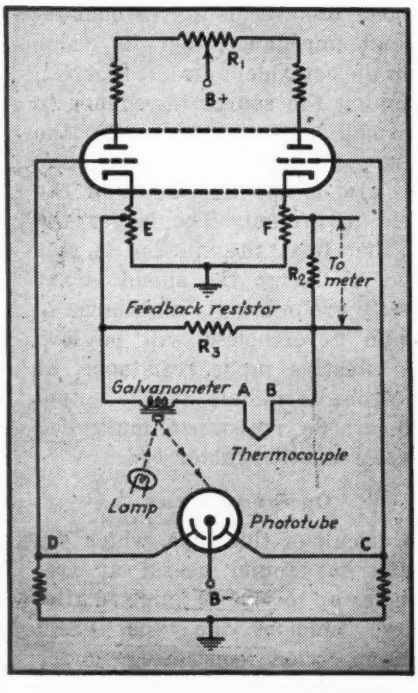


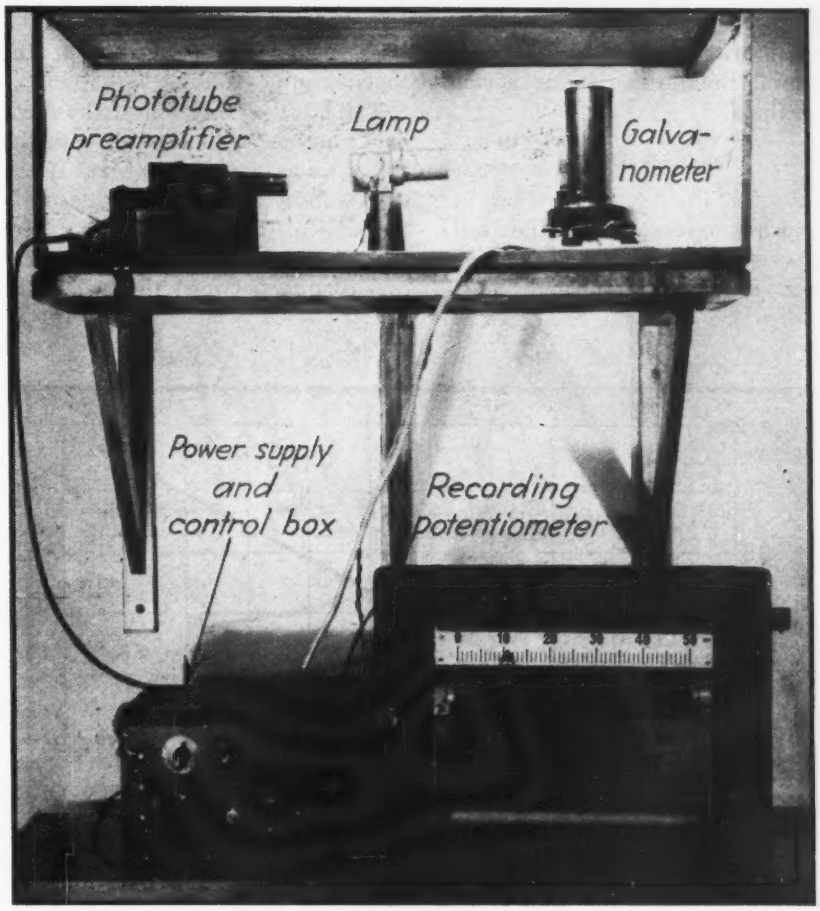
FIG. 1—Basic phototube amplifier circuit

The lamp used with the galvanometer has a straight vertical coiled filament. The beam of light from this filament is focused, by means of a lens in the lamp housing, on the cathodes of the twin phototube of the amplifier, the beam having been first reflected at the mirror of the galvanometer. The two cathodes of the phototube are separated by a space of 1/32 inch. The image of the filament is wide enough to straddle this space and to cover a strip on each cathode about 1/8 inch wide.

The meter used as an indicator of emf is a Brown Electronic strip chart potentiometer recorder, which

Galvanometer Amplifier

has proved to be highly satisfactory for use with the phototube amplifier. No noticeable zero drift exists and its readings are reliable within ±0.25 percent of full scale deflection. The model used has a span of 4 millivolts. The time required for full scale travel of the pointer is 11 seconds, but this can be reduced by changing the gear reduction of the balancing motor.



The phototube amplifier is the connecting link between a sensitive galvanometer and an electronic recorder. The optical system comprising the lamp, galvanometer mirror and phototube of the amplifier is best enclosed to eliminate stray light and temperature variations

Phototube Amplifier

The amplifier is built in two units. A control box contains the control knobs, selector switch, all the resistors in the measuring and amplifier circuits and the power pack.

In the vacuum-tube unit are mounted the triodes of the amplifier and the twin phototube. A projecting light shield prevents scattered light from affecting the phototube. When the system is in operation, the galvanometer, vacuum tube unit and lamp are enclosed in a box to keep the temperature uniform and to reduce further the effects of stray light on the phototube.

The operation of the phototube amplifier is illustrated by Fig. 1, a simplified diagram of the circuit. When there is no emf across the thermocouple terminals AB, the galvanometer coil is undeflected. Light from the lamp strikes the galvanometer mirror and is reflected to the twin phototube. The optical alignment of the lamp, galvanometer and phototube is adjusted so that the same amount of light falls on each cathode of the twin phototube.

The phototube load resistors are equal, and therefore the potential at points C and D are equal. To make points E and F equal in potential the two sections of the duotriode are balanced by R_1.

The measuring circuit is across points E and F. Whenever these two points are at the same potential, no current flows around this loop. The meter, which records the voltage drop across R_2, consequently reads zero.

When the equipment is in use in spectroscopic analysis, radiation falls on the thermocouple, raising its temperature and producing a small emf. This emf causes the galvanometer coil to deflect through a small angle. The resultant deflection of the light beam reflected from the galvanometer mirror then illuminates a greater area of one cathode of the phototube than of the other. The resulting unbalance in potentials at C and D is proportional to the thermocouple emf if the light beam is not deflected beyond that position where its edge just fails to strike one of the cathodes.

This difference in potential results in a like difference in potential at the grids of the duotriode. These changes in grid voltages, being amplified without distortion, produce a difference of potential between E and F which is proportional to the thermocouple emf. The potential difference between E and F is large enough to produce a drop across R_2 sufficient to actuate an electronic potentiometer recorder.

A sensitive galvanometer such as the one used here ordinarily responds to every type of mechanical

disturbance unless a vibration-absorbing mounting is provided. In this circuit feedback is used to keep the galvanometer coil steady in spite of mechanical disturbances and changes in line voltage which exist in practically all locations and to avoid the necessity for special mountings.

Feedback Circuit

Thus far, the analysis has not included a consideration of the feedback used. Current flowing between E and F through the small feedback resistor R_s introduces a small potential drop into the galvanometer circuit. This small potential is so directed that it is opposite to the thermocouple emf at AB. The circuit is so designed that this feedback voltage is 90 percent of the thermocouple voltage.

The steadying action of the feedback can best be described with the aid of an assumed vibration. If the coil suffers a deflection due to a mechanical disturbance, the deflection upsets the optical-electrical equilibrium between the two cathodes of the photoelectric cell. The difference of potential between points C and D is amplified, causing a current to flow through the measuring circuit which includes the feedback resistor R_s. The feedback voltage is of a polarity that opposed the assumed coil deflection and is within 10 percent of the voltage-equivalent of that deflection, and therefore prevents excessive deflection and holds the coil near its null position.

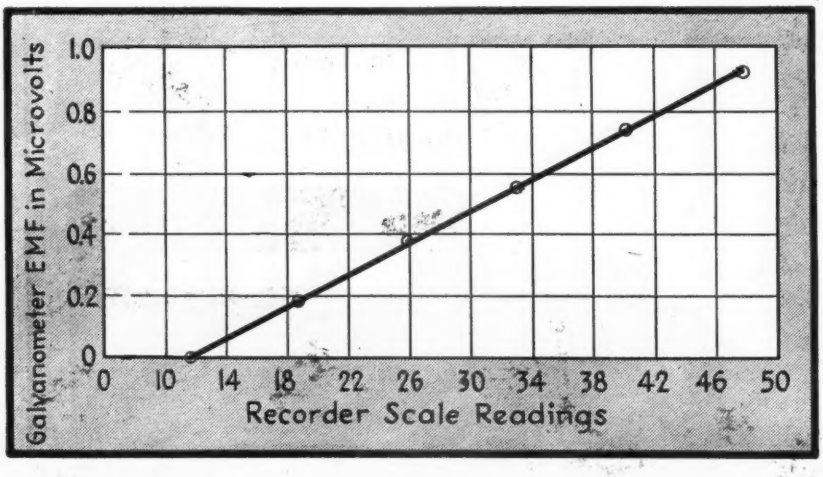


FIG. 3—Comparison of calibration over a period of four days illustrates instrument stability

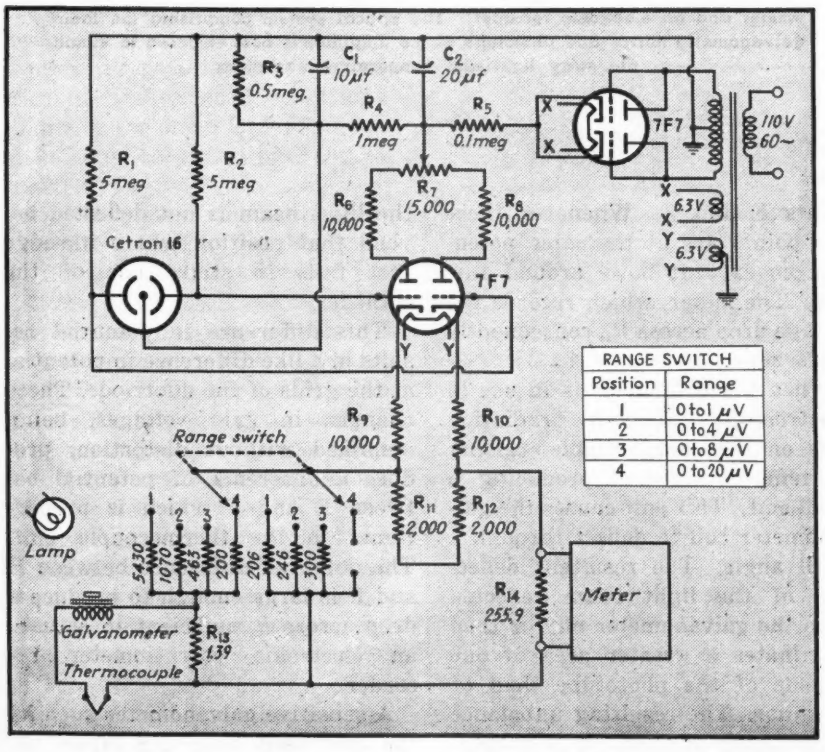


FIG. 2—Complete circuit showing component values for a four-range amplifier

Complete Circuit

In reducing the theoretical design of the phototube amplifier to a practical unit it was necessary to adapt the basic circuit to a multiple range circuit, reduce zero drift to a minimum, obtain maximum sensitivity and to secure constant calibration.

The basic circuit was changed to measure thermocouple emf in 4 ranges: 0-20 microvolts, 0-8 microvolts, 0-4 microvolts and 0-1 microvolt. A schematic wiring diagram, Fig. 2, shows the final circuit. Eight resistors were inserted in the measuring circuit to provide the required ranges. Each range is determined by a pair of resistors, one in series with the feedback resistor, and the other shunting the two in series as shown. The computation of the values of the resistors which determine the ranges was based on the following considerations:

(1) Output voltage regardless of the range is proportional to angular deflection of the galvanometer coil.

(2) The reflected light has just reached the position where it illuminates only one cathode of the phototube when the output meter to be used with this unit has reached full scale.

(3) The feedback voltage is at least 90 percent of the thermocouple emf.

Condition 2 means that the photoelectric unbalance is a maximum within its linear limits, and that at this unbalance four millivolts is obtained across R_{14}.

Precautions to Assure Stability

Reduction of zero drift was effected by eliminating as far as possible the sources of stray thermal emf in the measuring and galvanometer circuits. Spurious emf is

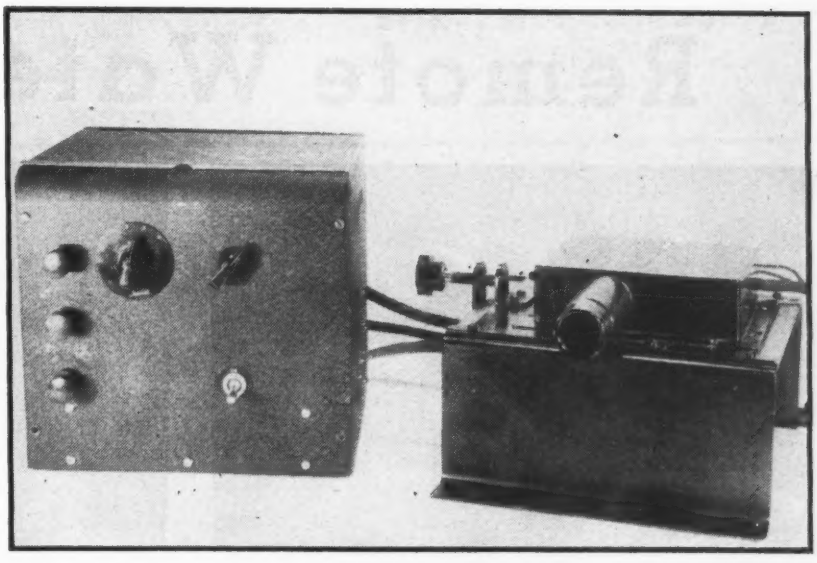
set up between a pair of junctions of two different metals at different temperatures. To reduce the sources of such stray thermal emf in the measuring circuit, the eight range resistors were placed close together and the surrounding space was packed with wool felt. For further reduction in thermal emf which gives rise to zero drift, the range resistors were made large compared with the feedback resistor. In case of an extraneous emf appearing in this part of the circuit, most of the potential drop would appear across a range resistor of at least 200 ohms and a relatively small drop would appear across the feedback resistor of 1.39 ohms.

Thermoelectric emf causing zero drift in the galvanometer circuit was eliminated by using only copper in that circuit. The three soldered junctions outside the galvanometer were fixed close together and the surrounding space was filled with wool felt. The galvanometer itself has five soldered joints, but it is reasonable to assume that they are protected from steep temperature gradients by the galvanometer housing. The feedback resistor, on account of its critical response to temperature changes, was soldered directly to one of the galvanometer leads in the meter base.

To keep the sensitivity as close as possible to its theoretical maximum value many precautions were taken to reduce induced 60 cycle a-c pickup and leakage currents to ground across insulators. To protect the grids of the amplifier tube from induced a-c emf, the tube was mounted one inch from the photocell so that the connecting wires were short. The power pack was mounted in a separate steel unit and connected to the amplifier and the phototube by shielded cable.

D-C leakage across the base of the amplifier tube was reduced by using a polystyrene tube socket. To prevent a-c leakage from the transformer to the measuring circuit, the transformer secondary was grounded at the center tap while the measuring circuit was designed to be a few volts above ground.

To prevent changes in calibration with temperature variations, Manganin resistors were used in the measuring circuit. The values of these resistors remain constant within ±0.006 percent for a ten degree F change of temperature.



The amplifier is built in two parts. Phototube, with projecting light shield and amplifier housing, is at the right. The power supply, range switch and balancing control are in a separate cabinet shown at the left

Amplifier Performance

The precision, or agreement of repeated measurements of the same quantity, for the 20, 8, and 4 microvolt ranges is ±0.20 percent, for the 1 microvolt range, ±0.75 percent. These figures take into account deviations due to reasonable mechanical disturbances of the galvanometer, changes in line voltage during operation, changes of calibration over a period of 2 to 3 days, and zero drift over the period of 1 hour.

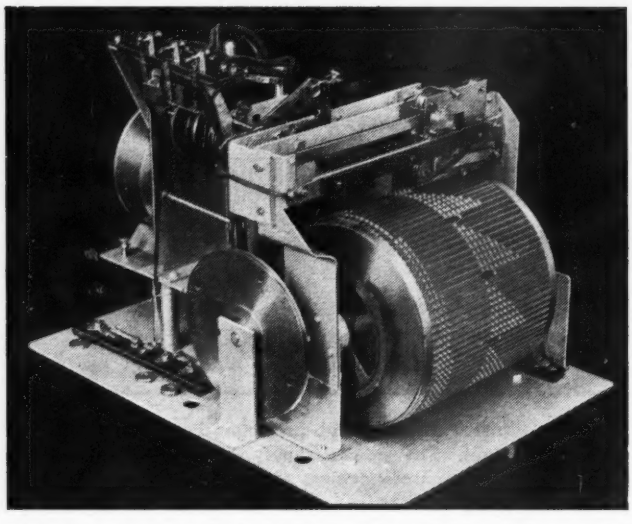
Accuracy of calibration is not only limited by systemic and incidental errors but also by the accuracy of the standard used in calibration. For the 20, 8, and 4 microvolt ranges, the emf of the standard (a potential divider across a dry cell standardized against a standard cell) was known to be within ±0.75 percent; for the 1 microvolt range, ±0.90 percent. Therefore, the absolute accuracy of the three higher ranges is ±1.0 percent; that of the lowest range is ±1.5 percent. These figures assume no zero drift. Accuracy defined here refers to the limits of error of measurement in percent of full scale deflection of the instrument.

The instrument is stable for runs of 2 to 3 hours, after it has been in operation for 24 hours, when all parts have reached thermal equilibrium. A zero drift of approximately 1.5 percent exists for the 0-1 microvolt range when the device has been running only 3 or 4 hours. The cause of this is a thermal emf in the galvanometer circuit.

Assuming no zero drift, the constancy of calibration over periods of 3 and 4 days, is apparent from the curve in Fig. 3. The line is drawn through points taken 4 days after the points represented by circles, with the ambient temperature varying between 80 degrees F and 85 degrees F. Similar curves plotted for the other ranges show equal stability.

The phototube amplifier offers possibilities for use with industrial instruments designed to measure small emf from a thermocouple or thermopile in infrared spectroscopic analyses. It is sensitive and yet stable. Its response is linear to the emf of the thermocouple. The use of a recording potentiometer permits continuous measurement. Further improvement in layout would reduce the drift. A heavier support would reduce the effect of wall resonance on the galvanometer. Even in its present form under reasonably quiet conditions, the resulting records permit reliable spectroscopic analyses.

Remote Water-Stage



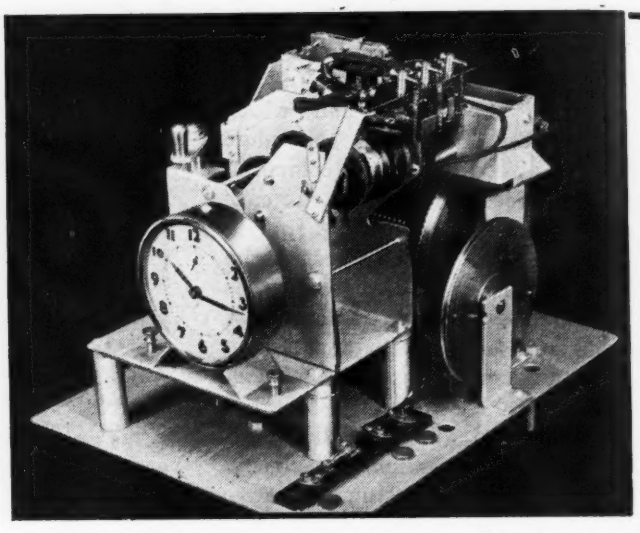


FIG. 1—Two views of the keying mechanism located near the flood-control dam. It converts liquid level into dots and dashes, and also identifies itself. Movement of a cord with a float at one end and a weight at the other turns the drum through a pulley and gears. A moving finger equipped with contacts "scans" a drum-line corresponding to calibrated depth

MUCH is being done on the North American continent to obtain and maintain adequate water supply for agricultural, industrial and domestic use. The high water levels of a flood season are being held in reservoir storage back of large dams, to be released later under control. Large areas of rich desert lands have been reclaimed by irrigation and still larger areas of old, established farm lands and cities have been made safe from the ravages of flood waters and soil erosion.

The need of water-stage measurements at remote points along rivers feeding the 16 major dams operated by the Los Angeles County Flood Control District, and at outlet gaging stations below the penstocks and valve outlets of the dams, led to the development of special devices for making and transmitting remote stream measurements.

Working models of radio water-stage indicators were built and tried under actual working conditions as early as 1936. The present type of gage was developed in 1937 and a number of these gages were completed and placed in operation in 1938 and 1939.

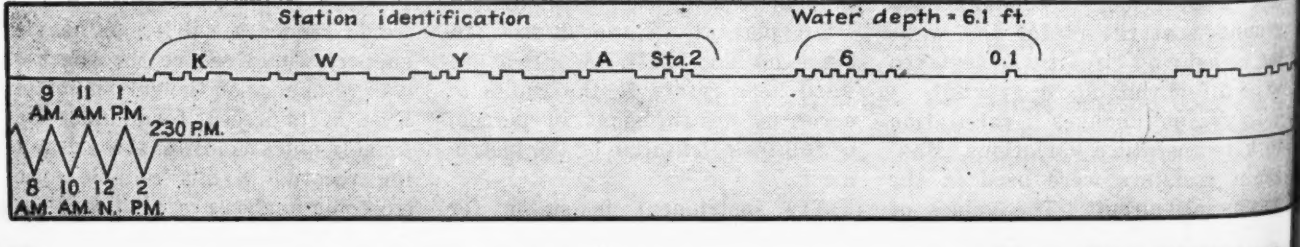
Radio Water-Stage Indicators

The remote transmitting gage we use is a device for keying a small battery-powered radio transmitter at predetermined intervals, giving the station call-letters and the water elevation in dots and dashes. Timing of the transmission schedules may be set to operate the keying mechanism on an hourly or daily basis. An additional electrical contact is provided to place the gage in emergency operation on a 15-minute schedule when the river elevation reaches a flood stage.

Figure 1 shows the keying mechanism with its coded water-elevation indicating drum. The position of the drum is determined by the elevation of a 12-inch copper float in a stilling-well below the gaging station. The float cable passes over the float wheel to a suspended weight. The drum is free to rotate with the changing water elevation, and the perforations at the top of the drum (directly under the contact trolley) correspond with the instantaneous level of the water in the stilling-well.

The keying trolley is driven by a small permanent-magnet-field type of electric motor operated by batteries. The contact trolley normally stands with all contacts open and the mechanical finger which follows the perforations of the drum slightly lifted to permit free movement of the drum. The station call-letters are transmitted on the forward trip of the keying trolley, as the code letters are cut

A typical length of tape, remotely recorded at headquarters by the machine illustrated in Fig. 2.



Indicators

By MAURICE E. KENNEDY
Communications Engineer
Los Angeles County Flood Control District
Los Angeles, Calif.

A float-controlled mechanism located near a flood-control dam keys a radio transmitter at intervals determined by an ordinary alarm clock, and depth data is automatically recorded at headquarters. The device may be used to transmit audio signals over conventional lines. A bridge-type indicator requiring a three-wire line is also described

in a Bakelite strip in front of the trolley. The return movement of the trolley drops a mechanical finger to the top set of drum perforations and impulses indicating the water stage are transmitted. This cycle of transmission is repeated three times and the gage shuts down.

Timing of the radio transmission schedules is accomplished by a clock and a motor-driven set of timing discs and clutches installed in back of the clock. The timing cylinder tilts mercury contacts at the pre-set transmitting schedule time and places the gage in operation. One of the discs is driven by the main motor and limits the operation of the gage to three repeats. The clock is of the "dollar alarm" variety, with slight changes to compensate for temperature variations. The movement in the clock is merely used as an escapement time-governor, the clock mainspring having been removed and a 15-lb lead weight and driving drum added. This timing system keeps surprisingly accurate time over the 30-day periods between service calls to the remote gaging stations.

The motor used to power the gage is a small p-m-field type used by builders of scale-model locomotives. It operates at 6 volts dc and draws approximately ½ amp under load. The motor speed is 9000 rpm at full load. The power developed by an 80-to-1 reduction worm gear, plus further reduction in chain driving gears, is far in excess of the actual power required to drive the gage.

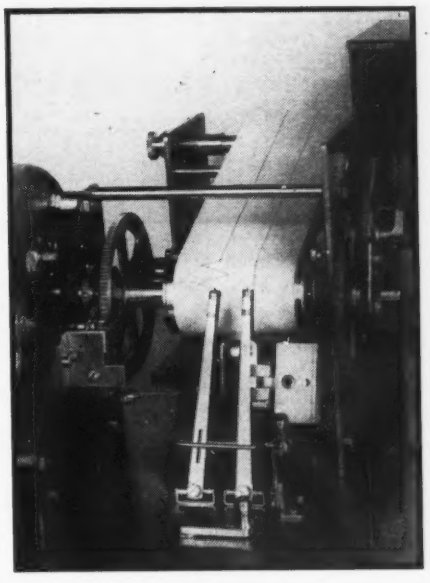


FIG. 2—Tape recording unit used at headquarters. The tape moves at a slow rate (about 5 ft per day) when no signal is coming in. When a signal is being received the tape speeds up to a rate of 25¾ inches in 2¼ minutes

Transmitters and Receivers

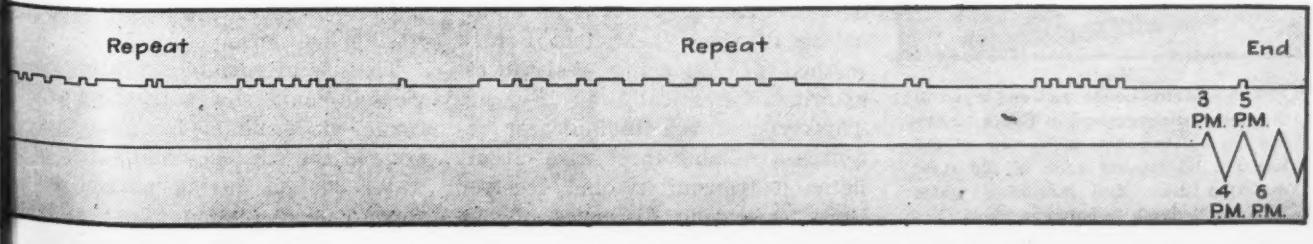
The radio transmitting gages use a small 4-watt crystal-controlled oscillator of conventional design, operating on 2248 kc. A type 71A tube is used because of its instantaneous-emission filament and rugged construction. Filament power is obtained from the gage's 100-ampere-hour storage battery. The plate power for the transmitter is supplied by 270 volts of heavy-duty B batteries.

The storage battery is replaced with a freshly charged battery once each month, when the clock is wound and the gage is serviced. The 15-pound clock driving-weights fall at the rate of six inches a day in 15-ft concrete stilling-wells. This makes it necessary to attend the gages on a 30-day schedule. An annual service of the gages includes cleaning, oiling, and the replacement of worn parts. The B batteries are usually replaced on an annual basis but during the past two years we have made an effort to conserve batteries by reducing the number of transmissions. At the end of two years service, the B batteries are still in good condition and ready for the coming season.

Radio signals from the gages are in the form of pure cw and may be received by any radio receiver (within the radius of the transmitters) capable of receiving A-1 emission on 2248 kc.

Receiving and recording equip-

It indicates that the river depth of the east fork of the San Gabriel river was 6.1 ft at 2:30 p. m.



ment at the District's dams includes a fixed-frequency superheterodyne receiver with a crystal-controlled r-f oscillator and a tape recorder developed in the instrument shop. The recorder is shown in Fig. 2. Incoming radio signals from the transmitting gages start the tape recorder, which inks the gage height with an ink-line similar to that made by a telegraph printer. This system is satisfactory except for occasional radio interference from stations on closely spaced adjoining channels.

Operation Over Wire Lines

Where isolated gaging stations are located near existing communication circuits or forestry lines, or are within two or three miles of a dam, the radio-type gage has been modified and simplified to operate on a wire circuit. The timing mechanism is omitted and a 20-cycle telephone relay is substituted to start the gage whenever a ringing-voltage is sent over the wire connection. The return information is transmitted by an audio-tone generator back over the same line. Simplex, phantom, or carrier-current systems lend themselves to this type of communication. Single-wire ground-line circuits are satisfactory for short-distance connections.

The one advantage of the wire-line system is the ability to ring and start the gage whenever information is desired and not having to wait for the next transmission schedule. Mountain storms or electrical storms have, on the other hand, made these gages inoperative on two or three occasions during the past several years.

Direct-Reading Remote Gage

A remote water-stage indicator which is direct-reading has been developed recently and is an application of the Wheatstone Bridge method of balancing resistances, shown schematically in Fig. 3. This type of remote indicator requires a reliable three-wire circuit between transmitter and receiver unit. Operating distances of one mile are possible but the only two gages so far installed are for the purpose of reading water stages immediately below the outlet valves of Pacoima and Sawpit Dams. These stations are located approximately 1000 ft below the dams.

Power potentiometers of the 500-watt type illustrated in Fig. 4 were used for transmitter and receiver variable resistors because of their mechanical ruggedness and large number of steps or contacts.

This system of remote measurement places one half of the bridge circuit at the remote gaging station, with the central arm driven by a float and cable in the stilling-well. The other half of the bridge, pictured in Fig. 5, is located in the control house on top of the dam. D-C power is applied when a reading is desired, the bridge is balanced by rotating a knob and watching a zero-center, 0 to 10-ma null indicator on the receiving unit, and the gage elevation is read directly on a pre-calibrated dial. The system is simple, accurate, and could be applied to numerous remote indicating applications.

The use of remote-indicating devices in connection with the operation of modern dams has greatly increased the efficiency and safety of water control during normal and storm periods.

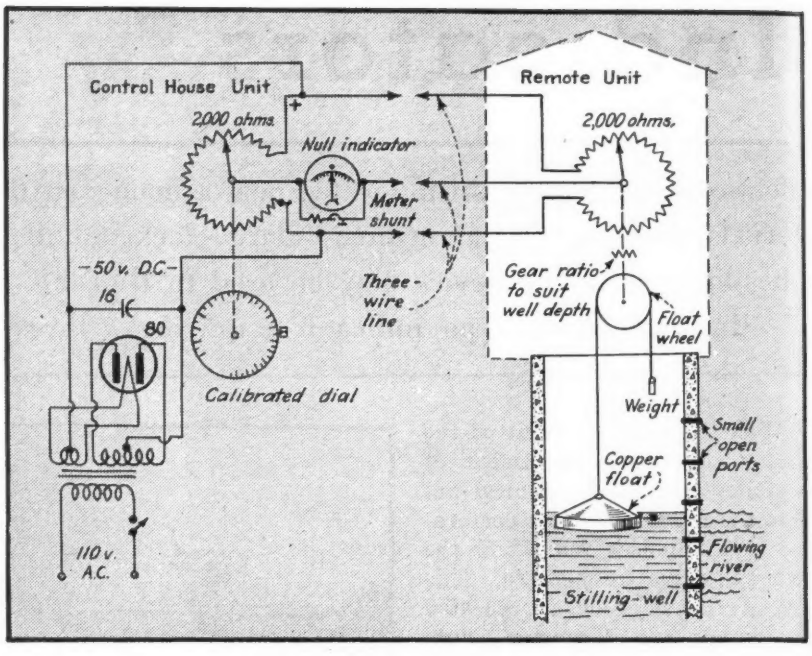


FIG. 3—Circuit of a highly accurate remote water-stage indicator using a three-wire line. Photos of the remote unit and of the control-house unit appear in Fig. 4 and 5

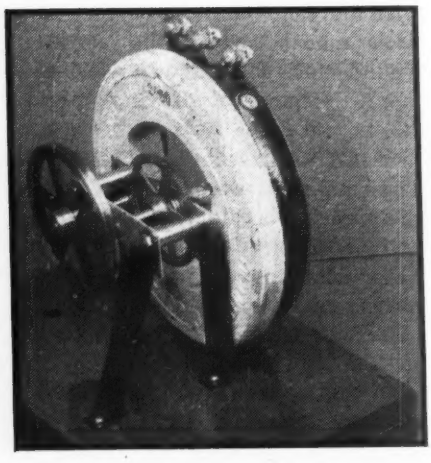


FIG. 4—Remote unit used in the system shown schematically in Fig. 3

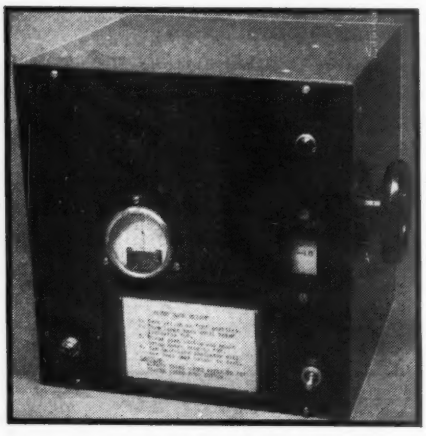


FIG. 5—Control-house unit employed in the circuit diagrammed in Fig. 3, showing the null-indicator instrument at the left, the adjustment knob at the right and the drum dial indicating water depth in-between

RELAYS IN Industrial Tube Circuits

Part III

Grid-controlled gas tubes operated from d-c power provide on-off relay control. With a-c power, the filter and method of firing the gas tube govern relay operation. The theory is extended to phototube relay control. A burglar alarm illustrates relay applications

By ULRICH R. FURST
Chicago, Illinois

THE addition of a control electrode to cold-cathode and hot-cathode gas tubes creates a group of electronic tubes which are especially well suited for industrial control applications. A great many circuits have been devised for such tubes, especially for the hot-cathode tubes (thyratrons). This discussion is restricted to their use in combination with relays.

Although the action of the control electrode (starter anode or control grid) is entirely different in cold and hot-cathode tubes, their performance can be expressed by their break-down characteristic, and therefore all considerations apply to both types.

D-C Relay Operation

The simplest case is relay operation from a d-c supply-voltage. When the voltage of the gas tube control electrode is increased, the tube becomes conducting when the controlling voltage just exceeds a critical value given by the tube break-down characteristic. The voltage drop across the tube is almost constant (it varies with ambient temperature) and the tube current is limited only by the load resistance, in this case the resistance of the relay coil.

The selection of the right values of relay current and coil resistance is a simple problem in Ohm's law.

Supply voltage minus tube drop is the available voltage for the relay coil. The necessary power consumed by the relay is a characteristic of the selected type of relay.

Sometimes it might be advisable to add an additional resistor in series with the relay coil to avoid the use of coils which are wound with very thin wire to obtain the necessary high resistance. Thin relay wire can easily break or corrode.

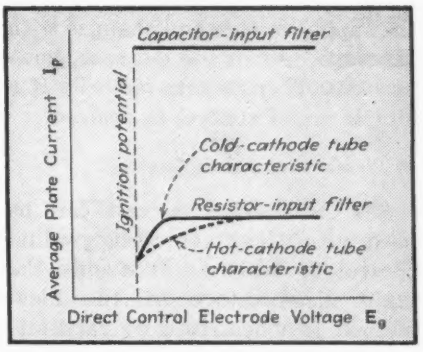


FIG. 1—These curves are for operation of the plate-relay circuit from an a-c power supply

Provisions have to be made to interrupt the discharge through the tube so that the control electrode can regain control after ignition. This circuit provides a simple on-off control and no gradual control can be obtained in this manner.

Types of A-C Powered Control

More interesting is the operation of tube and relay from an a-c supply voltage. In this case filtering of the plate current is important because current variation is obtained by variation of the fraction of the cycle during which the tube conducts instead by variation of the maximum tube current without change of the duration of the current flow as in vacuum tubes. But the same considerations and methods for the design of filters which were discussed before are applicable.

There are essentially three different methods of controlling the tube current: By variation of the d-c control-electrode voltage only (bias control), by variation of the d-c control voltage with a super-imposed alternating voltage lagging the plate-supply voltage by a constant angle (bias-phase control), and by variation of the phase angle between plate and control voltages with or without a superimposed constant d-c bias voltage (phase-shift control). All three methods are widely discussed in textbooks, so that their merits need not be discussed here in detail.[1]

Bias Control Calculations

The bias control method produces an abrupt change of the average plate current from zero to a large value which depends only on load impedance, filter circuit and supply voltage. This abrupt change occurs as soon as the d-c potential of the control electrode exceeds the break-down voltage of the tube for the peak plate-supply voltage. If a capacitor-input filter, a sufficiently large capacitor paralleling the relay coil, is used the plate current I_m approaches the value

$$I_m = (E_s - E_t)/R_c \qquad (1$$

where E_s, E_t, and R_c are the peak supply voltage, tube voltage drop, and coil resistance respectively. Increasing the d-c potential of the

control electrode beyond the ignition potential changes neither the average nor peak plate current. This condition is shown in Fig. 1. No gradual control can be obtained by this method.

Conditions are slightly different if no filter or a resistor-input filter is used. In this case the average plate current, which also flows through the relay, is calculated by averaging the instantaneous current over a full cycle. When the d-c potential of the control electrode exceeds the break-down voltage, the tube will fire at the positive peak of the supply voltage and carry current during the following quarter of the cycle until the supply voltage equals the tube voltage drop. A simple integration furnishes the following exact equation for the average plate-current I_a:

$$I_a = (E_a/2\pi R_a)\left\{\sqrt{1-(E_t/E_a)^2} - [E_t/E_a][(\pi/2) - \sin^{-1}(E_t/E_a)]\right\} \quad (2)$$

This equation should be used with cold-cathode gas tubes, because the tube voltage drop is larger than can be neglected. For thyratrons the tube drop is only a few volts and usually $(E_t/E_a) < 1$. Therefore Eq. (2) can be simplified to

$$I_a' = E_a/2\pi R_a \quad (3)$$

If the d-c control potential is increased still further, the average plate current rises rapidly to a maximum of twice the value indicated by Eq. (2) or (3). The suddenness of this rise depends entirely on the steepness of the curve representing the breakdown voltage of the tube as a function of the instantaneous plate voltage. If this curve is a horizontal line, as in most cold-cathode tubes, the average current rises immediately from zero to twice the value given by Eq. (2) or (3) because the tube conducts either all the time during which the supply voltage exceeds the tube voltage drop, or not at all.

For thyratrons this characteristic is usually not a horizontal straight line, so that there is a gradual change from the current indicated by Eq. (3), when the tube starts to fire, to twice this value. This is shown by the dotted line in Fig. 1.

Figure 2(a) shows that this circuit is not very effective for gradual control, because it allows a change of current between 50 and 100 percent of its greatest value for only a slight change of the control voltage indicated by Δe_g, and is also greatly affected by fluctuations of the supply voltage and changes with tube age. As in the d-c case, however, it will work satisfactorily if a simple on-off control is desired.

Bias Phase Control

The bias-phase method can be used with advantage when gradual control is desired. It avoids the main disadvantage of the bias-method just described by facilitating the shifting of the firing point. The signal on the control electrode consists of a variable d-c bias and a superimposed a-c signal with constant amplitude and phase and of the same frequency as the plate-supply voltage.

Just as in the bias method, the firing point is shifted by variation of the d-c bias, but the added a-c signal allows a considerably sharper intersection of the almost horizontal break-down characteristic with a steeper curve representing the control voltage, as shown in Fig. 2(b).

If a sinusoidal a-c component of this control voltage is used, a phase difference of about 90 deg. is the best, but this value is not critical. Of course other than sinusoidal signals can be used, as for example a sawtooth-wave as shown in Fig. 2(c), or any other gradually rising periodic voltage. A convenient method of obtaining a sawtooth wave is a half-wave rectifier operated from the a-c supply voltage with a capacitor input filter having a time-constant in the order of one second.

The control of the plate current obtained by this method is smooth and extends through a range of the controlling d-c voltage which is approximately equal to twice the peak voltage of the periodic signal superimposed on the bias when no filter or a resistor-input filter is used. This gives a convenient method of adjusting the circuit constants to obtain the desired operation. The average current can be varied from zero to twice the value given by Eq. (2) or (3).

With a capacitor-input filter smooth control can also be achieved, but the range of the controlling d-c voltage is only half that of the former as shown in Fig. 3, and the plate current varies from zero to a value given again by Eq. (2). This is due to the fact that the tube acts like a half-wave rectifier charging the filter capacitor.

The voltage to which the capacitor is charged is either the actual

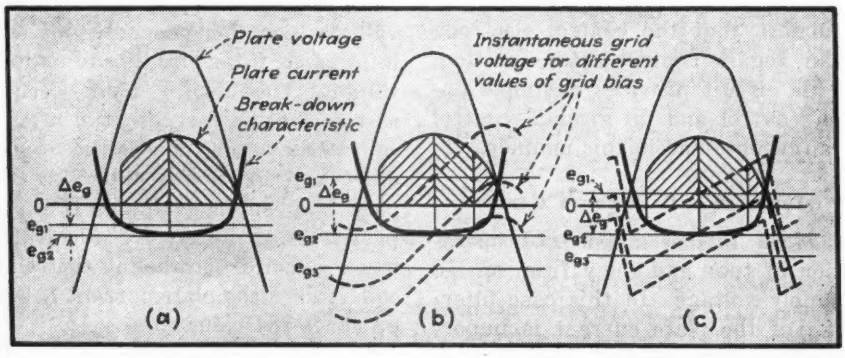


FIG. 2—As the direct grid voltage is changed, the instant during the cycle when the tube fires is changed. Superimposing an alternating component on the direct grid voltage as at (b) and (c) produces a sharper intersection of the resultant grid voltage with the gas-tube break-down characteristic than at (a). In each diagram Δe_g produces the same change in average plate current

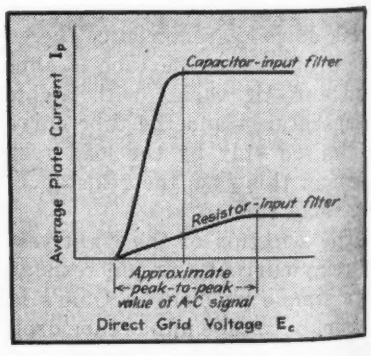


FIG. 3—Bias-phase control characteristics of a thyratron show the relative ranges over which continuous plate-current control is obtainable for the two extreme types of filter

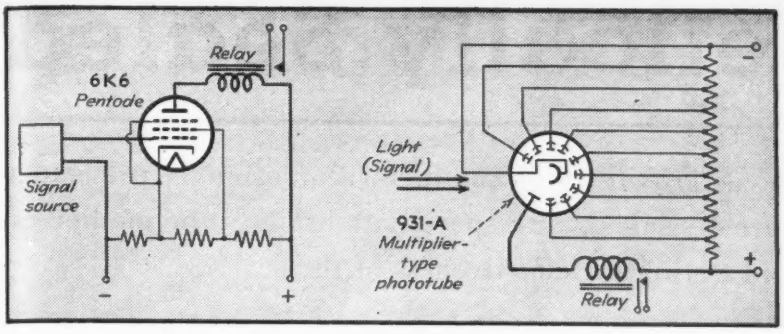


FIG. 4—The only essential difference between a phototube and a pentode for relay control is that the phototube signal is produced by light, whereas in a pentode the signal is produced by potential

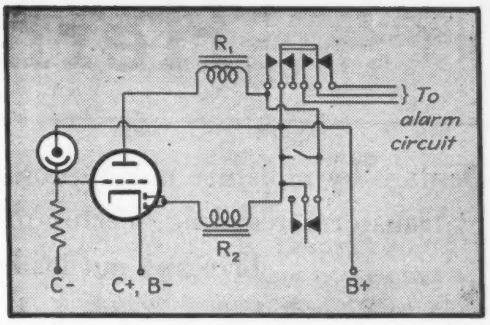


FIG. 5—Burglar alarm vacuum-triode relay-control circuit with automatic reset in case of power failure provided by auxiliary diode circuit

peak voltage of the power supply or the voltage at the instant of firing less tube drop, depending on which occurs later. Care must be taken that the maximum rated peak current of the tube which momentarily charges the capacitor is not exceeded.

Phase Shift Control

The third method of control, the phase-shift method, can be treated in essentially the same manner as the bias-phase method. There are no differences between both methods as far as the plate circuit containing the relay coil is concerned; the only difference is the way the firing-point of the tube is shifted.

Instead of using a variable d-c bias with a constant superimposed a-c signal, a constant d-c bias, which may be equal to zero, together with an a-c voltage is employed. This a-c voltage has the same frequency as the plate-supply voltage, but its phase can be shifted. The amplitude of this signal voltage may or may not be constant. The operation of this method is explained in text books on electronics so that no detailed description is needed here.

Filter Requirements

The two filter circuits described, capacitor-input and resistor-input, are the two extreme cases of a continuous series of possible filter-circuits rather than two typical cases. It is of great advantage in most cases to choose the circuit constants so that the actual conditions of operation lie between these two extremes. For instance, either it might be necessary to insert a small resistor between the plate lead of the tube and the filter capacitor to limit the current surge through the tube, or it might be impossible to make the filter time-constant (filter capacitance times relay-coil resistance) large enough. In both cases the average current will be less than that calculated for the capacitor-input filter, but more than the average current calculated for a resistor-input filter. The controlling action will be intermediate between th actions of either filter.

Phototube Relay Control

Although the tubes discussed in the previous sections cover the overwhelming majority of electronic tubes which can be used in conjunction with relays, other tube types, for instance the photo electric tubes with secondary-emission multipliers, can be treated in analogy with the types just described.

As an example, the multiplier phototube just mentioned has a family of curves which resembles that of a pentode. The only difference is that light intensity on the cathode serves as the independent parameter in the phototube instead of grid voltage as in the pentode. This phototube will behave exactly as a pentode with a grid voltage which varies in the same way as the light on the cathode of the phototube. The fact that an entirely different type of power supply is needed with this phototube does not alter the design considerations. In Fig. 4 basic relay control circuits using a pentode and a phototube are compared. Similarly, rules and equations can be applied to other tubes.

The behavior of circuits containing tubes and magnetic devices other than relays can be similarly analyzed and designed. Such other devices include solenoids, magnetic clutches, solenoid carbon-piles, meters and motors. The performance of these devices can be expressed by their resistance or voltage vs. current characteristics and current values typical of their action, and thus they can be treated like relays of equal properties.

Engineering Illustration

By way of showing how an industrial relay-control application can be solved, the burglar alarm mentioned in the first part of this series is illustrated in Fig. 5. The triode section of the vacuum tube provides the main relay control. Its operation is the same as that of Fig. 3 of Part II. The diode section provides protection against power failure.

In normal operation, if the photoelectric cell is darkened by the shadow of the intruding burglar, the self-holding relay R_1 in the plate circuit of the triode will drop out and stay inoperative until the push-button switch is momentarily closed. The second set of contacts of relay R_1 is used to operate the burglar alarm. The relays are, as is conventional, shown in their power-off positions.

If the circuit is so adjusted that relay R_1 operates sooner than relay R_2 during the heating of the tube, the latter relay shorts with its normally closed contacts the self-holding contacts of relay R_1 during this interval and thereby resets the circuit within a few seconds after power has been restored.

References

(1) E. E. Staff of M. I. T., "Electronics", John Wiley & Sons, Inc., New York, 1943, p. 307-319, and Millman, J. and Seely, S., "Electronics", McGraw Hill Book Co., 1941, p. 419-436.

Hermetically Sealed

Damage by moisture absorption, fungus growth, and conductor corrosion is prevented by transformer sealing. Techniques are described, with special attention to the method of bringing out leads and testing for effectiveness of the seal

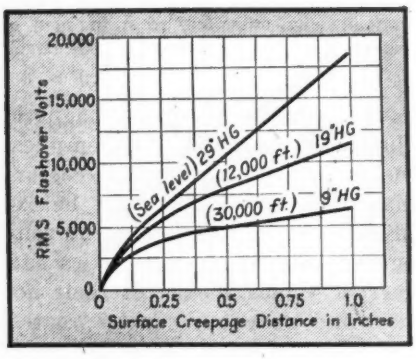


FIG. 1—Reduced atmospheric pressure has this effect on flashover voltage vs. creepage distance. Hermetic sealing has the effect of keeping working parts at constant pre-determined pressure

HERMETICALLY sealed transformers are those enclosed in cases which are impervious to a specified set of ambient conditions. Certain tests have been set up for the units to resist, and the required hermetic seal can be defined as that which will withstand the rigors of this qualification.

In transformers, there are three principle causes for internal failures not resulting from overload or improper operation. These are: (1) failure of insulation because of moisture absorption, (2) failure of insulation because of lowered air pressure which decreases the flashover voltage, (3) opencircuiting of a winding because of electrolytic corrosion brought on by the absorption of moisture.

Failures of the third class are most common in the type of transformer where a very small-diameter conductor is used, and when the relative humidity is very high. The action is accelerated in battery equipment where the winding is connected permanently to a positive potential and the core or other windings to the negative terminal. This corrosion will be negligible if high-grade insulation materials are used and no moisture is present.

The curves of Fig. 1 indicate the effect of lowered atmospheric pressures on the surface flashover voltage. Where equipment must operate at altitudes above sea level in excess of 30,000 feet and where the operating voltages are greater than 5000, it becomes necessary to provide very large relative creepage spacings between coils. This makes the unit unduly large for a given rating and complicates the design.

Moisture can be forced into an imperfectly sealed transformer by a breathing action caused by differential internal and external air pressures. This differential pressure can be created by either altitude or temperature changes, and since all impregnating materials are hygroscopic to some extent, insulation resistance of the windings will decrease upon continued exposure to even very small quantities of moisture.

Insulation resistance will also be found to vary as the temperature of the unit is varied. Figure 2 indicates the resistance-temperature characteristic of a typical small audio transformer. Very carefully controlled conditions of manufacture and choice of insulation materials are required to maintain 100 meg at 100 deg C in this type of unit. The usual insulation resistance of small transformers at an ambient temperature of 25 deg C, is above 1000 meg at the time of manufacture.

Insulation resistance will also be found to be a function of voltage gradient. If the voltage is increased above a certain critical value, the insulation resistance will suddenly decrease to a very low value, a high current will flow, and the resulting heat and chemical action cause rupture of the insulation.

The life of a transformer may also be seriously affected in tropical locations by fungus growths. Suitable steps must be taken to inhibit such growths on the unit.

Keeping Moisture Out

It is evident that extended life of a transformer requires all moisture to be removed during the manufacturing process and that moisture be prevented from entering the unit during service. One way to keep the equipment dry is to maintain it at a high temperature. However, the electrical energy or fuel required for this purpose may make such means impractical. The other logical alternative is to seal the unit hermetically in a case so moisture cannot enter.

It is definitely known that a transformer made by conventional production methods will operate under conditions of low relative humidity for long periods of time.

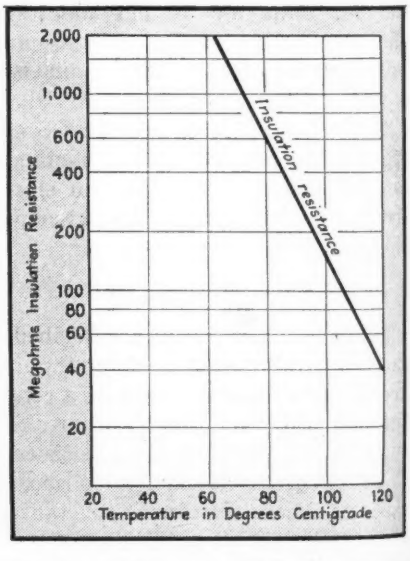


FIG. 2—Decline of insulation resistance with increasing temperature makes it difficult to maintain 100 meg at 100 deg unless insulation materials are high quality. Sealing of units keeps out moisture which degrades insulation resistance

Transformers

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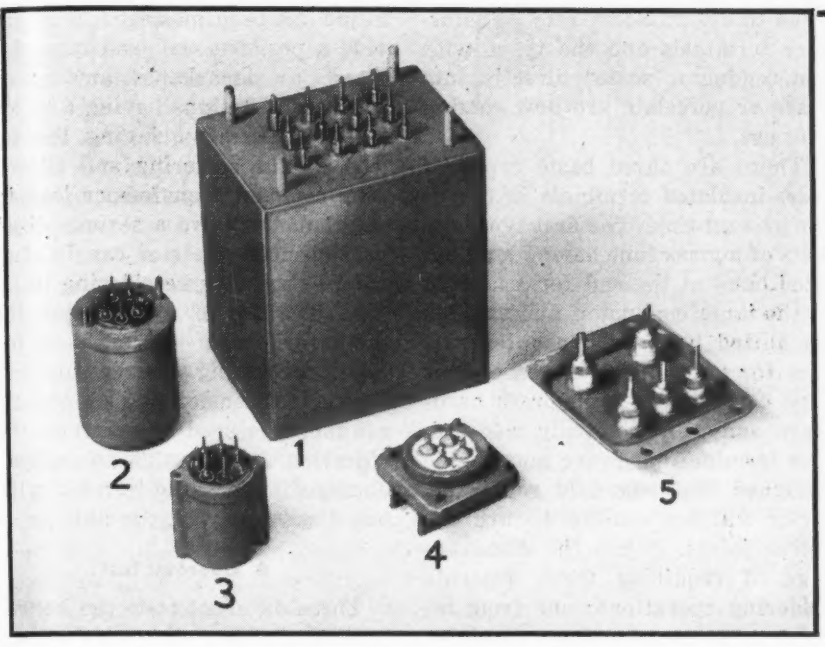

Folded-steel case (1) contains hermetically-sealed transformer whose windings are brought out to glass-Kovar sealed terminals. Units (2) and (3) involve 7-terminal glass headers solder-sealed to cases. In (4), the terminals are soldered to a ceramic disk sealed into the transformer cover, while (5) has individual ceramic terminals soldered into extruded holes

Therefore, if an effective hermetic seal can be secured, this same coil and core construction can be used without change of coil production methods.

The hermetic sealing of transformers presents four distinct problems. First is the case design and construction; second is the terminals or means of getting the electrical connections to the outside of the case from the coil; third is the sealing of seams and case joints; and, fourth is the method of checking the final job to be sure it is adequately sealed. Acceptable solutions to all these problems have been found and improvements are constantly being added.

Three types of cases are well suited for production: one-piece drawn-metal with cover, folded sheet metal with welded or soldered seams, and cast metal. The drawn metal cases require tooling but have low unit costs and are easy to seal. The folded sheet metal cases are very easy to fabricate and allow great flexibility of case design. A style with separate top and bottom covers and stud-bolt mounting is the most popular construction. The coil and core are internally bracketed to the mounting studs so that the case joints are not required to carry the weight of the unit. Die-cast metal cases are inexpensive and suitable for high production but require tooling and special soldering techniques for attaching the covers.

The drawing of Fig. 3 shows a type of folded sheet metal case construction. It is important that the case wall have the support bands in such position that the unit will rest on the cover and not on the case wall when it is bolted in place.

It is equally important to exercise caution in the choice of metals used for external case parts to avoid any possibility of electrolytic corrosion of the case during service in salt atmosphere. Some combinations of metals (such as brass and aluminum) are particularly vulnerable. It is not advisable to use corrosive soldering fluxes on the case joints—the most acceptable type is rosin and alcohol. No difficulty in soldering should be encountered by experienced operators if the case parts have been previously hot-tin dipped, or electrotinplated.

Finish must be specially suited for use over tin. This is one of the most difficult surfaces to work with in getting good adherence of paint. As tin actually accelerates rather than inhibits corrosion of iron or steel areas that may be exposed in the plating, it is necessary to secure a complete coating and advisable to use a corrosion inhibitive primer. Iron oxide and zinc chromate primers are widely used for this purpose.

Terminal Problems and Types

A wide variety of terminals are offered for use on hermetically sealed transformers. The basic requirements for such service are as follows: (1) Attachment to the case to be simple, quick, and effective; (2) Adequate current-carrying capacity—suggested standard ratings are 4, 15, 30 amp; (3) Tinned surfaces for easy solder connection; (4) Insulation must withstand the required flashover voltage—suggested standard ratings for rms test at sea-level are: 2000, 3500, 7500, 12,000, 20,000 and 35,000 volts; (5) A minimum external insulation surface creepage distance of $\frac{1}{8}$ in. and a minimum internal creepage distance of $\frac{1}{8}$ in.; (6) Insulation must not favor fungus growth, must be nonhygroscopic, and must have a non-porous surface; (7) Size, as small as possible, especially in diameter, as it is often necessary to group many of them on the cover of a small unit; (8) low unit cost; (9) Ability to withstand—operation under conditions of temperature from −55 deg C to +100 deg C, soldering operations of attaching leads, and a differential air pressure of at least 20 psi; (10) Insulation resistance greater than 1000 meg at all temperatures up to at least +85 deg C.

There are several types of hermetically sealed terminals. First is the kind produced through fusing a sealing glass to certain metals by heating until the metal oxide fuses into the surface of the glass. Second

is porcelain, metallized by fusing a metallic coating into the surface glaze. This coating is then tinned and soldered to other metal parts with conventional tin-lead solder. Third is a similar metallic coating for glass, and fourth is the metal part fused directly into the glaze of a ceramic insulator.

A hermetic seal can also be obtained by means of rubber or synthetic rubber gaskets, and by means of pressure joints and suitable cements. The use of porcelain bushings with cemented paper gasketing has been successful in high production for many months but has the disadvantage of high cost and the excessive labor required for the very exacting sealing process. The gasketed joints all require proper centering of the parts, and proper clamping pressure to maintain the seal. These joints which are gasketed or cemented are most susceptible to leakage after a thermal cycling over the temperature range of −55 deg C to +85 deg C.

It is also possible to seal terminals in a laminated or molded phenolic terminal plate. The molded type is not a guaranteed method because of contraction of the phenolic material in cooling, and because the surface can be permanently damaged by flashover. The material is hygroscopic and must be treated to reduce moisture absorption and retard fungus growth. Terminals which are riveted into a laminated phenolic plate are sealed by a combination of pressure and cementing. A coating of varnish such as clear Glyptal is often used to improve the seal and to reduce moisture absorption. These methods all depend upon a certain amount of patching and there is no assurance that all items produced will be properly sealed.

It must be pointed out that such cemented phenolic terminal board construction is superior to unsealed or open construction. Cases are on record where radio equipment has been accidentally submerged in salt water for several days, and transformers so treated were found undamaged after a surface cleaning.

Glass and Ceramic Seals

Considerations of moisture absorption, fungus growth, carbonization of surface by flashover, ease of cleaning, and effective sealing all point toward the use of glass or ceramics as a preferred terminal insulation material. Available metalizing processes have made it possible to design some very satisfactory terminals and the types with the conductor sealed directly into glass or porcelain are now coming into use.

There are three basic types of glass-insulated terminals in use at the present time. The first type consists of a glass tube having a metallized band at the end for soldering to the inner conductor, and another metallized band on the outer surface for soldering to the case. This type can be used with brass hardware and is quite easily soldered. The terminal hardware must be so designed that any field repair activity will not readily disturb the solder joints. It has the disadvantage of requiring three separate soldering operations; one from insulator to case, one from insulator to inner conductor pin, and a third from the coil lead to the conductor.

The second type consists of a glass plate with metallized rim and having several terminal holes with metallized edges. Several terminals may then be placed in this single plate. The unit is satisfacotry if properly designed so a difference in coefficient of thermal expansion of the glass and metals will not cause strains and cracks. The disadvantages are the relatively large size required for the inner solder seals, the possibility of disturbing the terminal soldering when external leads are soldered to the terminals, and the high cost and long time required to install all the terminals on the glass plate.

The third type consists of a central metal conductor sealed to a glass having substantially the same temperature coefficient of expansion as the metal. The outer rim of the glass can be either metallized for soldering or sealed into a metal eyelet. A glass header can be designed and constructed with one or more terminals as required. This construction gives a positive seal, is not easily damaged in the field, and lends itself to automatic machine manufacture so that unit cost can be very low for mass production. The ends of the conductor can be flattened and pierced to simplify external lead connection.

Solder-sealed porcelain bushings have been available and in use for several years. They are relatively easy to install after the proper technique has been mastered, they provide a positive seal, and can withstand a remarkable amount of shock. The designs having a hollow terminal permit bringing the coil lead up for soldering and allow a very compact transformer lead insulation, but have a serious disadvantage that the seal can be damaged by careless resoldering in the field. The use of a solid stud terminal, crimping of the hollow terminal, providing a screw top or a separate extension lug on the tip, are methods used to overcome this objection. It is possible to replace a damaged hollow stud terminal without disassembly of the unit.

A Rigorous Test

Three different tests can be used to check the hermetic seal of a transformer. These are: the thermal-immersion test, the ambient immersion test, and the production sealing test. The thermal-immersion test is the most rigorous, and transformers capable of passing it should be suitable for use in severe tropical climates. The ambient immersion test is applicable to transformers having a seal of intermediate quality. The production sealing test is intended to detect transformers in a production line when they have a very definite leak in the seal.

Transformers for the thermal-immersion test are conditioned for several hours at 40 deg C until all windings have reached this temperature and then measurements are made of the dc resistance of windings, of insulation resistance, and of dielectric strength. Then the following thermal cycle is repeated five consecutive times. Two chambers are used, one maintained at +85 deg C and the other maintained at −55 deg C.

Start at ambient room temperature, then place in plus 85 deg C chamber for 1 hour, then remove to minus 55 deg C chamber for 1 hour, then return to room temperature.

After the above cycle is repeated five times the unit is ready for the five immersion cycles. Two separate baths are provided containing saturated solutions of sodium chloride in water; one maintained at +8

deg C and the other maintained at 0 deg C.

Each immersion cycle will consist of the following: place unit in 85 deg C bath for 1 hour, then remove to ambient room temperature for 5 minutes, then place in 0 deg C bath for 1 hour, then remove to room temperature for 5 minutes.

After this cycle is repeated for five consecutive times the unit is washed with clear water and dried with an air blast. Then measurements are made of insulation resistance and dielectric strength. Following this the unit is again stabilized at 40 deg C and the d-c resistance of all windings measured. A transformer is considered to have failed if the insulation resistance drops below 100 meg at 500 v dc, if the d-c resistance of any winding changes more than 5 percent, or if the unit does not withstand the dielectric strength test.

The purpose of the thermal cycle is to cause expansion and contraction of the case parts by subjecting the unit to a range of temperature much greater than it will encounter in service. Then the unit is immersed in hot water to heat up the case and increase the internal air pressure. If leaks are present, air will be expelled. Then when the hot unit is placed in the cold water, the relative internal pressure will be decreased, and water will tend to enter through the leak. The presence of this salt water in the case is then detected by either a decrease in the insulation resistance or by failure in the dielectric strength test.

The necessary equipment for conducting such a thermal-immersion test can be readily improvised if necessary. The hot chamber can be maintained at 85 deg C by means of heater elements and a thermostat switch. The cold chamber can be maintained reasonably close to −55 deg C by the use of dry ice. The water baths should be quite large to maintain the temperature when the units are immersed.

Tests on a single unit are not conclusive, and it is usual practice to test from six to ten units in each test group. Experience has shown that most failures will be detected by a very marked decrease in the insulation resistance. This lowered insulation resistance may not be accompanied by any change in d-c resistance of the windings or by failure to withstand a dielectric strength test.

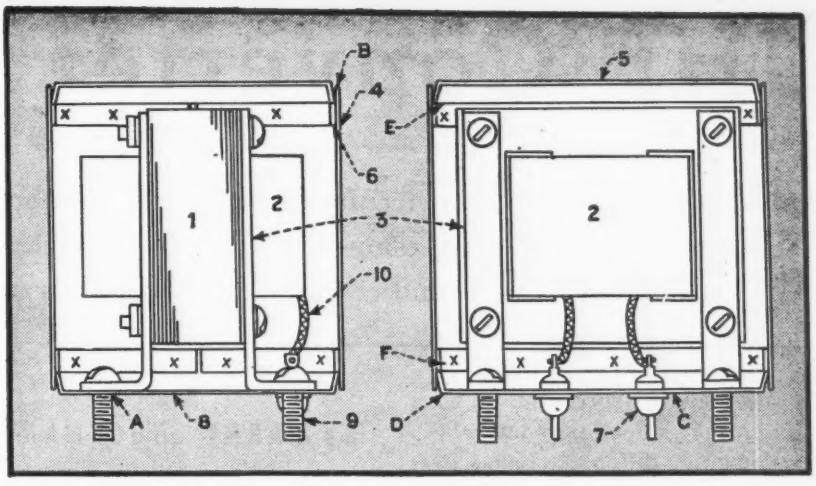

FIG. 3—Inside, a typical hermetically-sealed transformer has this assembly: (1) laminated core, (2) coil winding, (3) core brackets, (4) case body, (5) case cover, (6) cover band, (7) glass-seal terminal, (8) bottom cover, (9) mounting studs, and (10) coil leads. At point (A), the stud, bracket, and cover are soldered watertight and mechanically secure. Solder-sealing of cover (B) after potting and terminal eyelet (C) are shown. Necessary projection of cover beyond case is illustrated at (D). Cover-support bands (E & F) are spot-welded to case and unit is filled with potting compound to top of (E). Parts (3, 4, 5, 8, and 9) are electrotinned

Two Easier Tests

The ambient-immersion test is much simpler. The unit is immersed for 24 hours at room temperature in a saturated solution of sodium chloride in water. At the end of this period the unit is removed, washed in clear water, air dried for a period not to exceed one hour, and tested for insulation resistance and dielectric strength. The unit is considered to have failed if the insulation resistance falls below 50 meg at 500 v dc, or if it does not withstand the dielectric strength test.

It is not considered advisable to deliver units for use which have been subjected to either the thermal-immersion, or the ambient-immersion tests. There is always the possibility that some slight amount of moisture may have been driven into the unit but not enough to cause immediate failure under the applied tests. This could result in very short service life.

The production sealing test requires a bath of clear water maintained at approximately 190 deg F (88 deg C). A transformer at room temperature is immersed in this water for a period of one minute. A stream of bubbles from any seam or seal normally indicates a leak and such a unit should be regarded as failing the test. If no bubbles are ejected it means that the unit passed this test and some assurance is given that there are no obvious leaks.

If a small leak is detected at a soldered joint, the place about the leak should be wiped dry immediately upon removal of the unit from the water. The location of the leak can then be marked and the pinhole in the solder seam repaired. The unit should then be retested for leaks, and this test followed by an insulation resistance test. The chances of water entering the unit are quite remote, if the excess water is removed from the region of the leak before the unit begins to cool.

Terminal assemblies and case assemblies can also be checked by applying internal air pressure of 10 to 20 psi by means of a suitable fitting and then immersing the case in water.

A transformer manufacturer who is building hermetically sealed transformers should apply some test such as the production sealing test to 100 percent of production. It provides a continual check on workmanship and detects those transformers which are definitely not hermetically sealed. A short trial of such a test will immediately indicate its value.

UHF Converter Analysis

Methods of analyzing mixer circuits are reviewed. Mathematical analysis of converters is abandoned in favor of conversion diagrams from which uhf converter characteristics can be studied. Diode and crystal conversion diagrams illustrate the method

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A FREQUENCY CONVERTER is essentially a device for the creation of sum or difference terms by means of a nonlinear characteristic. The desired frequency component is selected by the output circuit. The two fundamental parts of a frequency converter are the mixer and the local oscillator. The mixer is double-controlled, the signal and oscillator waves constitute the two controlling quantities.

Types of Converters

Nonlinearity is, in single-input mixers, provided by the curvature of the output-current vs input-voltage characteristic. In such a mixer one control voltage provides a sliding Q point for the other, the sliding taking place along the path of operation. This path of operation remains fixed. Such a device may therefore be referred to as a sliding Q point or fixed path of operation converter.[1]

A double-input mixer is not necessarily nonlinear when the oscillator control voltage is zero. The nonlinearity may be entirely due to the oscillator voltage. Conditions are best described in terms of gate effect, the transconductance of one control-electrode being a function of the voltage on the other control electrode.

Signal-electrode transconductance variation may be visualized as an oscillator-voltage controlled shifting of the Q point back and forth between adjacent signal electrode characteristics. When acted upon by both control voltages, the point of operation follows a path that describes a sequence of noncoinciding loops. In the general case the path of operation does not repeat itself after one complete difference-frequency cycle. If the ratio between signal and oscillator frequencies is an irrational number, the path will never repeat itself.[2] A device such as this can be referred to as a shifting Q point or changing path of operation converter.

For broadcast frequency-converter design the above classification provides two fundamental types of characteristics to which mathematical analysis can be applied to give equations describing mixer action. In computation we use two steps. The first step involves an analysis of the mixer circuit to determine the voltages on the nonlinear element, and the second step requires the use of these voltages in equations which yield the mixer output.

Analytic Expressions for Converter Operation

Assume that the first step has been successfully passed. The general procedure in the second step depends upon the form in which the information about the nonlinear element is available — in graph-

From a paper presented at the National Electronics Conference, Chicago, 1944.

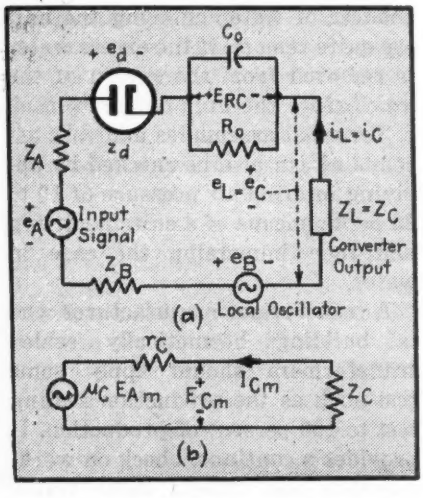

FIG. 1—(a) Basic diode converter with bias network R_0C_0 and i-f load impedance Z_c, (b) Equivalent circuit of (a)

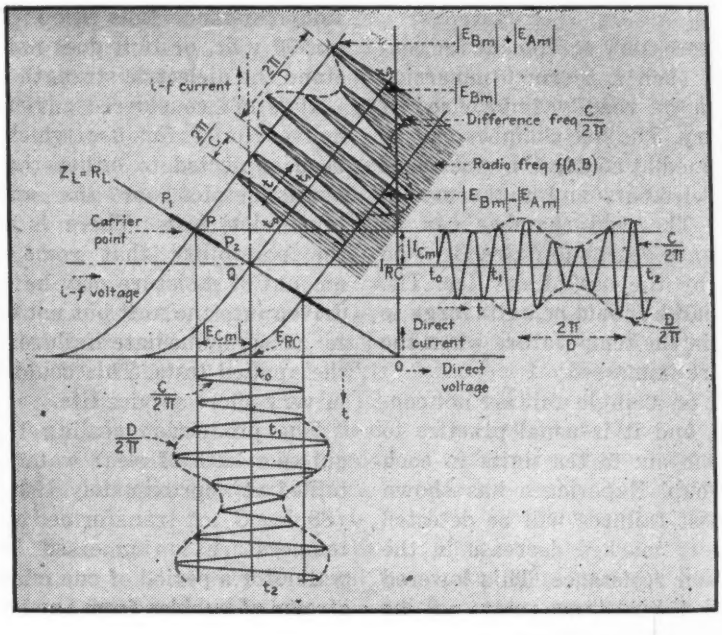

FIG. 2 (at right)—Converter rectification

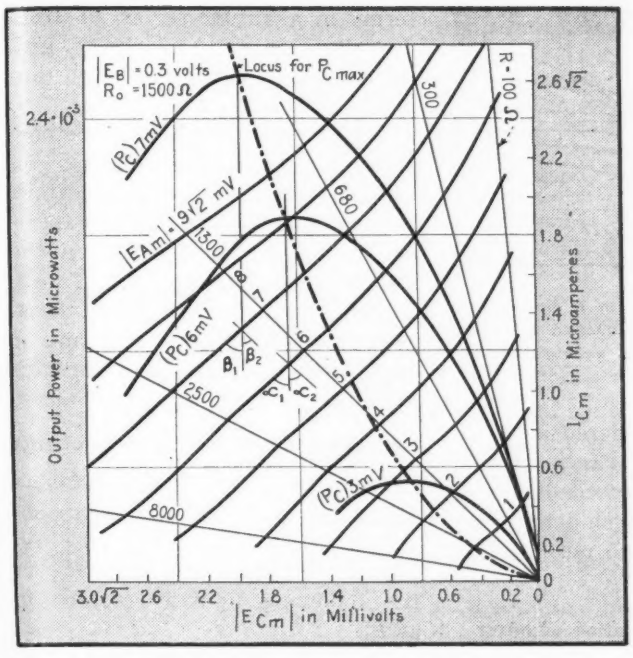

FIG. 3—Conversion diagram for uhf diode on which has been plotted the i-f output power as a function of the signal-wave amplitude and i-f load impedance

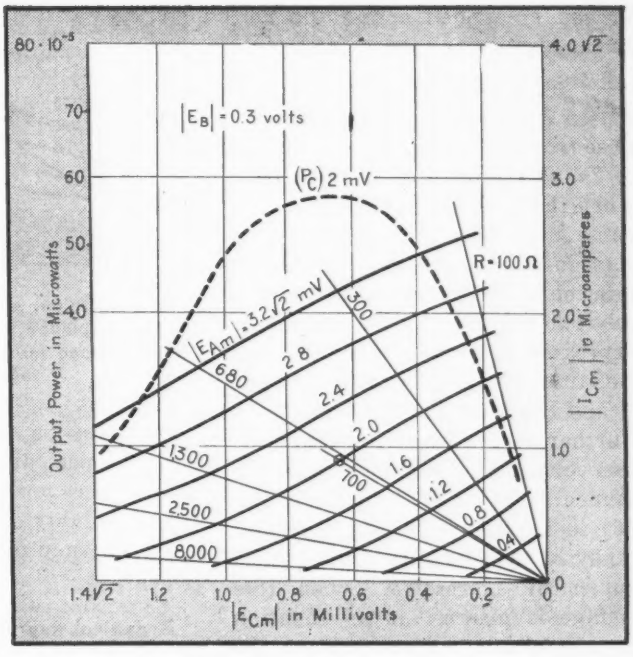

FIG. 4—Conversion diagram for crystal converter on which has been plotted power output for a 2 mv input signal as a function of i-f load impedance

ical or analytical form. Graphical form is the most likely both in the case of converter design on paper and in the case of measurements on an available nonlinear element. With this graphic characteristic and the applied voltages known, output current can be plotted in the form of a wave.

To analze this output wave $i(t)$, we may consider Fourier analysis as one possible method. If this wave repeats itself for each i-f cycle of period $2\pi/C$, it may be expressed by the Fourier series

$$i\,(t) = i_0 + \sum_{n=1}^{\infty} i_n \cos nCt \qquad (1)$$

Another possible method for determining output is the Taylor-series expansion. For two variables the expansion is

$$\Delta i = \sum_{n=1}^{\infty} \frac{1}{n!}\left(\frac{\partial}{\partial e_A}\Delta e_A + \frac{\partial}{\partial e_B}\Delta e_B\right)^n i \qquad (2)$$

The fourth term in the expansion is $d\Delta e_A \Delta e_B$, where coefficient d is $\partial^2/\partial e_A\ \partial e_B$. We only deal with the quadratic terms $(n = 2)$.

Consider for simplicity a double-input mixer with both input characteristics approximated by straight lines. The first derivatives are constants, therefore the term with coefficient d will be the only one left. Quantity d may be referred to as the coefficient of nonlinearity as it indicates the available amount of gate-effect.

Assuming signal and oscillator control voltages of the form $E_{Am} \cos At$ and $E_{Bm} \cos Bt$, where m is used here to indicate maximum, we obtain, by developing the fourth term, the equation

$$i = d\,E_{Am}\,E_{Bm} \cos At \cos Bt \qquad (3)$$

$$i = \ldots + \frac{1}{2} d\,E_{Am}\,E_{Bm} \cos (A - B)\,t \qquad (4)$$

where the last term represents the desired intermediate frequency. It is in general quite difficult accurately to determine higher-order derivatives from a given characteristic, and to find d may not be a convenient procedure.

A method for determining output quantities was described by M.J.O. Strutt.[3] The fundamental idea is to invent an empirical equation which fits the given or measured characteristic of the nonlinear element. A suitable equation is the exponential series

$$i = \sum A_n e^{a_n e} \qquad (5)$$

where a few coefficient-pairs (A_n, a_n) have to be determined from the given characteristic.

Output current can be computed if the coefficients and the voltages e on the nonlinear element are known. Each term in the expansion, which in some cases may be limited to two terms, contains a factor of the form $e^{k \cos \omega t}$, which periodic function is most easily dealt with if expanded in a Fourier series with Bessel functions as amplitudes. Each term in Eq. (5) contains the product of two series, providing a number of product terms, one of them yielding the desired difference-frequency.

In the methods discussed above it was assumed that the voltages on the nonlinear element were known. This assumption is seldom fulfilled at high frequencies. Also the conventional changing-path-of-operation devices cease to function properly at such frequencies, and fixed-path-of-operation devices such as uhf grounded-grid triodes, uhf diodes and crystals, and various types of uhf oscillators employed in autodyne types of circuits are commonly used. Under these conditions a graphical method of presenting converter data is preferable.

Converter Circuit Equations

This conversion-diagram method has been tried on uhf diode mixers for which the basic circuit is as shown in Fig. 1(a). The voltage e_d across the nonlinear element is to a first approximation

$$e_d = [a]\,E_{Am} \cos At + [b]\,E_{Bm} \cos Bt - E_{Cm} \cos (Ct + \varphi) - E_{Bc} \qquad (6)$$

where the symbols $[a]$ and $[b]$ indicate the fractions of the voltages

e_A and e_B applied across the nonlinear element. As an example

$$a = z_{dA}/(Z_A + Z_{BA} + z_{dA}) \qquad (7)$$

where Z_{BA} is the impedance of the B source to a current of frequency $A/2\pi$. The symbol z_{dA} designates z_d when the applied frequency has the value $A/2\pi$. Here z_d is used to represent, in general, the voltage-current relation of the nonlinear element; a relation that frequently cannot be expressed in simple form. Z_d is a function of e_B, e_C, and E_{BC}, while e_C and E_{BC} are both functions of e_B. Further, e_C is a function of E_{BC}, the bias voltage produced by the circuit-elements R_c and C_c. Therefore, Eq. (6) is of implicit form and cannot easily be approximated by a simple numerical expression. When this voltage is inserted in an equation for output current, matters may be complicated beyond the limit for engineering consideration.

Furthermore modern converter theory deals with the transconductance characteristic of the mixer-oscillator combination rather than the current-voltage characteristic of the mixing device.[4, 5, 6] Thus the local oscillator is not considered directly, and the resulting transconductance variation caused by the oscillator is made the fundamental basis for the discussion. This is the main reason for the introduction of the terms sliding Q point and shifting Q point converters. This transconductance variation may be written by the Fourier series

$$g_m(t) = g_{m0} + \sum_{n=1}^{\infty} g_{mn} \cos n Bt \qquad (8)$$

Introducing the symbol e'_d for the expression given in Eq. (6) when the second and last terms are removed, and transformed to constitute Eq. (8), we obtain

$$i = g_m(t)\, e'_d = \left\{g_{m0} + \sum_{n=1}^{\infty} g_{mn} \cos n Bt\right\} \left\{[a] E_{Am} \cos At - E_{Cm} \cos (Ct + \varphi)\right\} \qquad (9)$$

which equation gives the desired output term when expanded with Fourier coefficients.

This method is the foundation for the terminology suggested in the introduction. We may formulate the following statement regarding the modern viewpoint on frequency converter action: A frequency converter may be considered as a device with periodically varying transadmittance or transconductance, the periodicity of which determines the frequency of each output component.

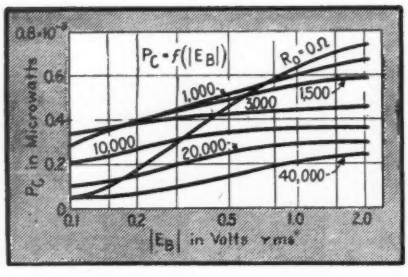

FIG. 5—Output power of a diode converter is plotted as a function of oscillator voltage for seven values of bias resistance

Graphical Representation of Mixer Action

Diagrams such as the large signal detector rectification diagram of Fig. 2 can be used to present mixer operation in place of the mathematical expressions previously discussed. This diagram shows one load line, $Z_L = R_L$, and one characteristic, $|E_{Bm}|$. The diagram applies to any nonlinear device and in particular may apply to a circuit similar to the one in Fig. 1(a) with e_B as the injected voltage.

The large-signal detector with E_B as the injected voltage produces a direct current $i = I_{BC}$ and a direct voltage $e_L = E_{BC} = R_L I_{BC}$. Equations relating, by means of three detection coefficients, variations in the applied voltage e_B to variations in the output current I_{BC} and output voltage E_{BC} can be obtained from the similarity between this and conventional triode characteristics. These equations can, as well, be obtained from the linear terms in a Taylor series, or from consideration of underlying geometrical relations upon which diagrams of this type are based.[7]

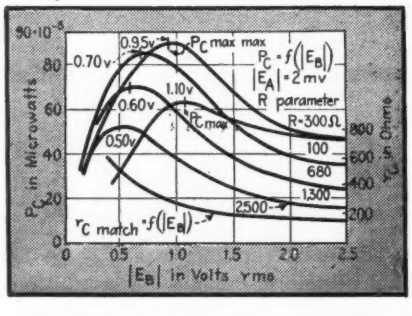

FIG. 6—Crystal converter curves plotted from sets of conversion diagrams show the i-f power output as a function of oscillator voltage for different values of i-f load impedance

The conversion-diagram method, presented in lecture courses on vacuum tubes at Cruft laboratory by Professor Chaffee, is an experimental method centered upon the nonlinear element and its i-f load. Information obtained from measurements is collected in diagrams of such form that theoretical investigation of mixer circuits is aided.

Measuring Conversion Characteristics

The data for plotting conversion diagrams is experimentally obtained with resistance R_L replaced by tuned load $Z_C = R_C$, in the following figures referred to as R.

An example of a uhf-diode conversion diagram, obtained from measurements, is given in Fig. 3. Such a diagram may be visualized as the i-f axes system with origin in Q, Fig. 2, lifted out and presented in form of a separate diagram. Actually each load line in the conversion diagram, Fig. 3, represents a particular part of the rectification diagram of Fig. 2. A similar conversion diagram for a crystal converter appears in Fig. 4.

The measurement set-up for obtaining conversion diagrams includes an A source, a B source and an i-f detector. Both signal generators A and B must have negligible output impedances in comparison with the average impedance of the nonlinear element; this is a severe requirement for generator B, which must deliver an output of several volts. The i-f detector input impedance is variable in steps. Each setting of this switch gives a particular load line in the diagram to be obtained.

The procedure is to choose suitable values for the parameters and take a run of i-f detector input-voltage vs. signal-voltage E_{Am} for a set of i-f input impedances. This procedure yields one complete conversion diagram. If repeated for various values of one of the parameters, the procedure yields a set of conversion diagrams. One or more sets of conversion diagrams are needed for full investigation of the behavior of a particular mixer. Curves plotted from these sets

describe how converter characteristics vary as functions of such parameters as oscillator voltage.

Measurements may be performed at the frequency at which the converter is to operate, or at a lower frequency.

Measurements at a lower frequency are easier to perform, but the results may not apply to the converter when operating at its assigned frequency without extensive corrections. This is particularly true for uhf triodes and diodes because of their dependence on transit-time phenomena.

Mixer Conversion Coefficients

The i-f output components i_c and e_c and input voltage e_A are related via the three conversion coefficients g_{mc}, g_c, and μ_c. These coefficients are evaluated from a conversion diagram of the form shown in Fig. 3, the evaluation being extended over the entire region of the diagram. The coefficients are

conversion transconductance

$$g_{mc} = \frac{I_{cm}}{E_{Am}}\bigg|_{\substack{\text{small amplitude}\\ E_{cm}=0}} \tag{10}$$

conversion conductance

$$g_c = \frac{I_{cm}}{E_{cm}}\bigg|_{\substack{\text{small amplitude}\\ E_{Am}=0}} \tag{11}$$

conversion resistance

$$r_c = \frac{1}{g_c} \tag{12}$$

conversion amplification factor

$$\mu_c = \frac{g_{mc}}{g_c} = \frac{-E_{cm}}{E_{Am}}\bigg|_{\substack{\text{small amplitude}\\ I_{cm}=0}} \tag{13}$$

Using the similarity with conventional triode theory we find that the equivalent plate-circuit equation for converters is

$$I_{cm} = \mu_c E_{Am}/(r_c + Z_c) \tag{14}$$

where E_{Am} is the reference quantity for complex current I_{cm}. Equation (14) represents the equivalent series circuit, shown in Fig. 1(b), but by rewriting Eq. (14) the parallel form of equivalent circuit can be obtained.

If the A wave is amplitude modulated, the C wave will be amplitude modulated. The coefficients relating the differentiated variables may be referred to as variational coefficients, and are:

variational conversion transconductance

$$g'_{mc} = \frac{\Delta I_{cm}}{\Delta E_{Am}}\bigg|_{\substack{\text{small amplitude}\\ \Delta E_{cm}=0}} \tag{15}$$

variational conversion conductance

$$g'_c = \frac{\Delta I_{cm}}{\Delta E_{cm}}\bigg|_{\substack{\text{small amplitude}\\ m=0}} \tag{16}$$

variational conversion resistance

$$r'_c = \frac{1}{g'_c} \tag{17}$$

variational conversion amplification factor

$$\mu'_c = \frac{g'_{mc}}{g'_c} = \frac{-\Delta E_{cm}}{mE_{Am}}\bigg|_{\substack{\text{small amplitude}\\ \Delta I_{cm}=0}} \tag{18}$$

The equation has the form

$$\Delta I_{cm} = \frac{\mu'_c m E_{Am}}{(r'_c + Z_c)} \tag{19}$$

Variational coefficients are obtained from the Q point region of the conversion diagram. Equations (14) and (19) are used in design work in the same way as similar equations for large signal detectors.

Interpreting Conversion Diagram

The conversion diagram in Fig. 3 represents a uhf 9004 diode, measured at 7 Mc, the lowest measurement frequency employed. This diagram is taken from a series of six. Bias resistor R_b has a particular value for each diagram in the series. The i-f power P_c is plotted as a function of load resistance R for $E_A = 3$, 6, and 7 mv, and it is seen that maximum power in each case is reached when $\alpha_1 = \alpha_3$, $\beta_1 = \beta_3$, etc. These equalities indicate the matching condition $R = r_c$.

Examples of curves plotted from sets of conversion diagrams are shown in Fig. 5, where P_c is given as a function of E_B for different values of R. The curves show that while self-bias does not contribute to increased output when E_B is large, self-bias will give a considerable increase in power when E_B is small. For small E_B there exists an optimum value of R_b (approximately 1500Ω) which is not very critical.

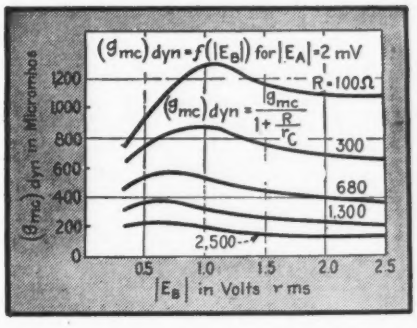

FIG. 7—Curves similar to the ones in Fig. 6 show crystal dynamic transconductance as a function of the oscillator voltage for different values of i-f load impedance

Figure 4 shows one crystal mixer conversion diagram taken from a series of six. Partly because of the double-conductivity of the crystal, there exists an optimum value of E_B, yielding a maximum value of P_c. The optimum value of E_B is a function of i-f load resistance R. These conditions are brought out in Fig. 6, where curves show that the pair (E_B, R) can be so chosen that each one of the quantities appears with its optimum value. Output power then reaches its greatest possible value $P_{c\,max\,max}$.

Many other curves can be plotted from crystal mixer conversion diagrams, for example, the $(g_{mc})_{dyn}$ curves in Fig. 7. Here

$$(g_{mc})_{dyn} = g_{mc}/\left(1 + \frac{R}{r_c}\right) \tag{20}$$

Output current is calculated as $(g_{mc})_{dyn} E_{Am}$. When current and R are known, output power is determined.

Equation (19) is of interest for calculations of modulation output, modulation rise, and modulation envelope distortion. However, results are frequently obtained by direct graphical construction in the conversion diagrams.

Conversion diagrams provide a standard procedure for collection of design data. The diagrams describe the behavior of a particular nonlinear element by curves plotted from sets of conversion diagrams. It is possible by means of such curves thoroughly to compare various samples of a particular type mixer.

The author wishes to thank Professor E. L. Chaffee for use of his idea of the conversion diagram method, and for valuable suggestions concerning its practical application as described in this paper.

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HIGH AND LOW-PASS Filter Design

By C. J. MERCHANT
The Brush Development Co.
Cleveland, Ohio

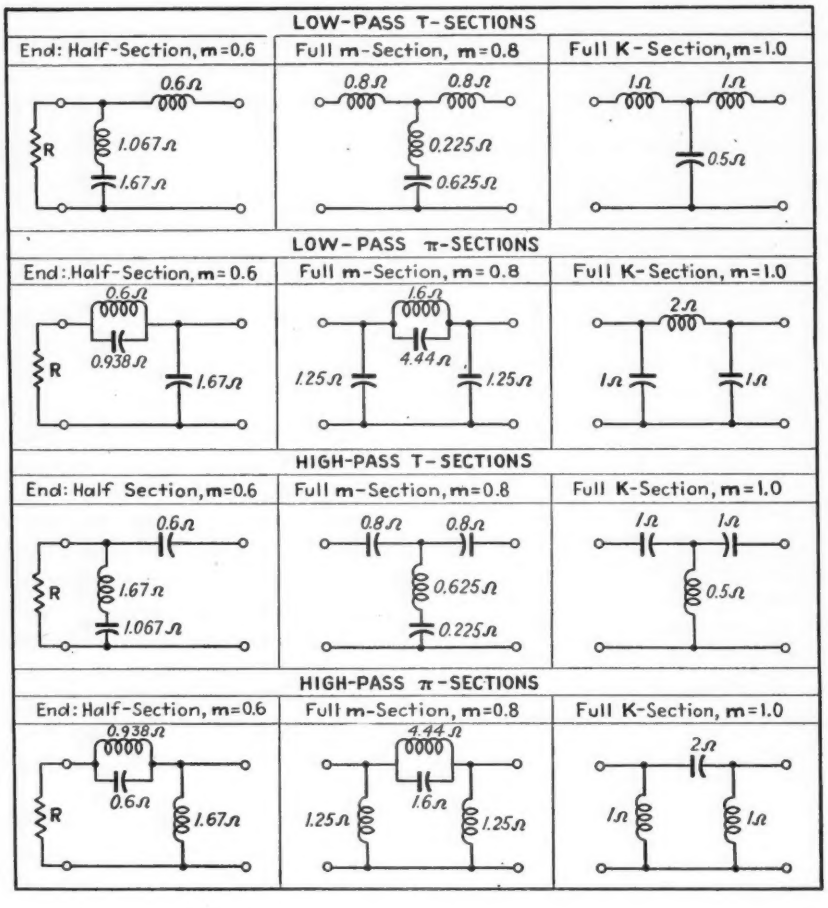


FIG. 1—Generalized impedance chart from which impedances are calculated by reactance slide-rule if terminating impedance and cut-off frequency are given

MUCH of the arithmetical drudgery of high- and low-pass audio-filter design can be eliminated by the use of a reactance slide-rule. For example, the formulas for L and C in a single constant-K high-pass T-section are $L = R/4\pi f_0, C = 1/\pi f_0 R$, where f_0 is the cut-off frequency and R is the terminating resistance. A simple rearrangement of these expressions gives $2\pi(f_0/R)L = 1/2$ and $1/2\pi(f_0R)C = 1$ or, in other words, L is the inductance whose reactance at the frequency f_0/R equals 1/2 ohm, and C is the capacitance whose reactance at the frequency f_0R equals one ohm.

The method can be extended to other types of sections, and a multi-section filter can be designed with only two settings of the reactance slide-rule, once at f_0/R for the inductances and once at f_0R for the capacitances. In multi-section filters the sharpest cut-off consistent with high attenuation outside the pass-band is realized by using terminating m-derived half-sections with m = 0.6, a full m-derived section with m = 0.8, and one or more constant-K sections.

Figure 1 gives the values of the reactances in ohms in such sections, the coils being evaluated at f_0/R and the capacitors at f_0R.

For example, to design a three-section low-pass filter of T-sections with R = 500 ohms and f_0 = 1000 cps, first set the rule at 1000/500, or 2 cps, and find the inductances whose reactances at 2 cps are those given on the chart. To find the capacitances, reset the rule at 1000 × 500, or 500 kc, and find the capacitances whose reactances at 500 kc are those given on the chart. The complete filter and its attenuation characteristic are given in Fig. 2.

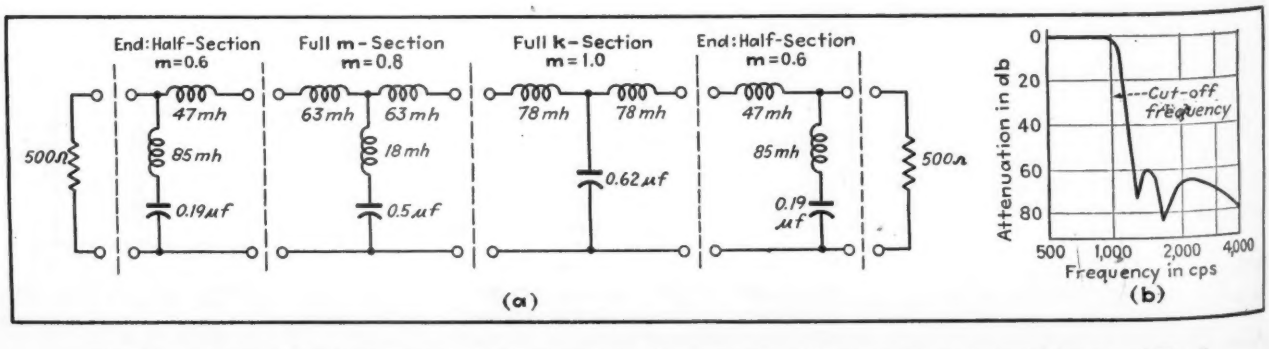
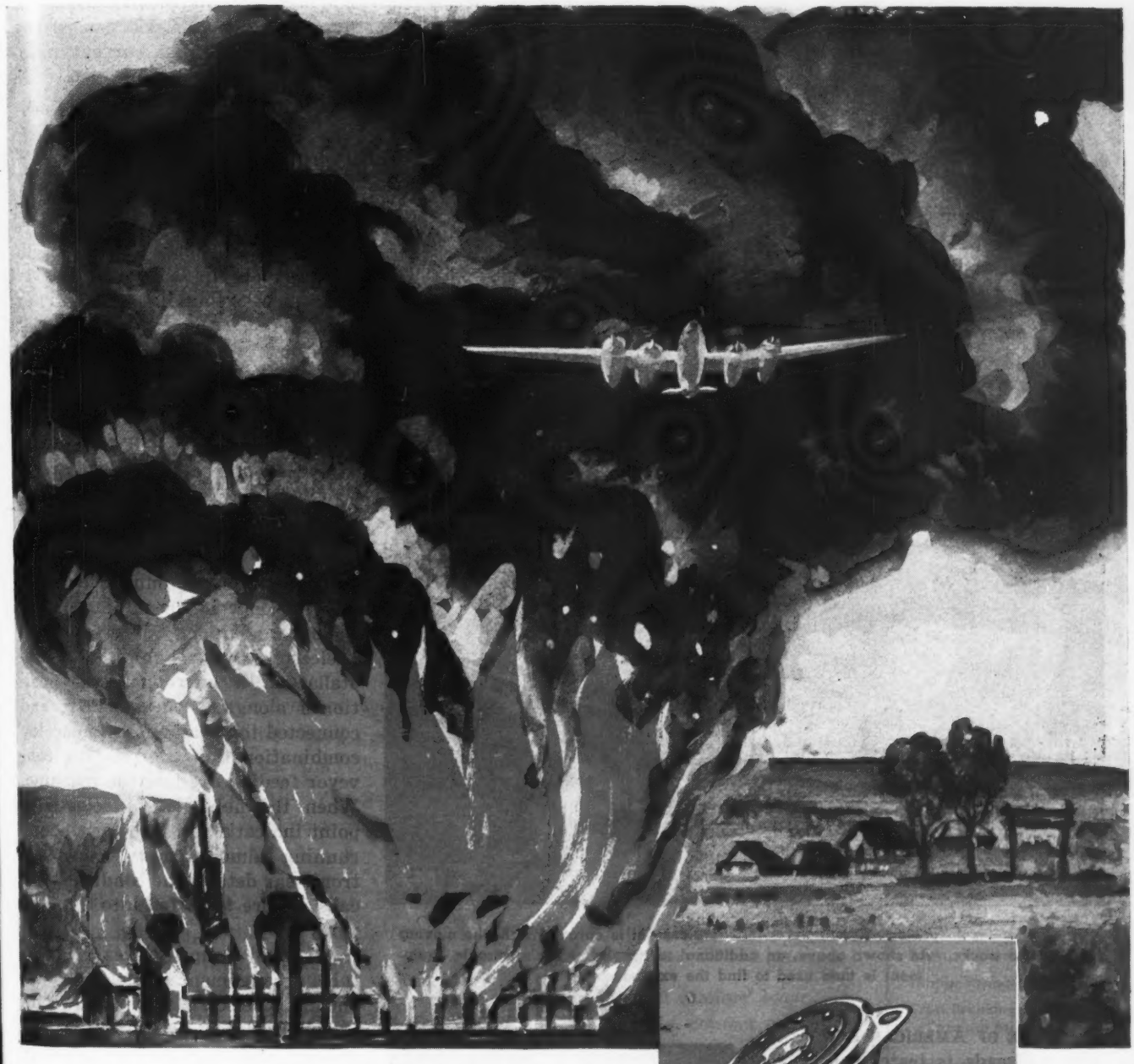


FIG. 2—Illustrative filter design values and attenuation characteristics of low-pass filter designed by use of Fig. 1

More often than not the socket in service is a "CINCH"



IT'S "KNOW HOW"

For reliable Communication all factors must be coordinated. So the CINCH contribution to the electronics program, the radio tube socket is a record of achievement. From the first socket manufactured sixteen years ago to the complete line now in service everywhere . . . a volume of increase that always exceeded the pace of the industry. Such a record signifies "KNOW HOW". As evidence of intensive research and resourceful engineering, CINCH was the first in the field with a complete line of miniature socket assemblies, together with nut straps, shield and associated items.

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Filler Necks ★ Octal Sockets ★ Lugs
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Mobile Testing of Railroad Rails

When a rail is suspected of having a defect, white paint is sprayed from the moving car on the tracks. As shown above, an additional test probe of the electronic equipment is then used to find the exact location

TRACKAGE OF AMERICAN and Canadian railroads is tested with electronic equipment operated by Sperry Rail Service. These rail-fissure detector cars checked about 165,000 miles of rail in 1943 and their findings resulted in replacement of nearly 100,000 defective rails.

In testing, the cars move over the tracks at a speed of from six to nine miles an hour, stopping each time a defect is found. They average about 30 miles in a 12-hour day. The detector cars are self-propelled by gas-electric drive and contain electronic detecting and recording apparatus. As the car moves, an operator checks tape on which a continuous record of the condition of both rails is revealed. The rails are pre-energized, and defects, their extent and location, are clearly indicated by distinctive marks caused by breaks in electrical current passing through the rail and picked up by the search unit which is attached to the underside of the car.

Tape in the recording unit of the rail-fissure detector is watched by a technician as the special electronically equipped car moves along the railroad tracks

A fleet of 17 detector cars works from dawn to dusk on a seven-day schedule. Each car is a self-contained unit carrying a crew of five men, and has complete living facilities, including cook's galley, shower bath and sleeping quarters. They travel from coast to coast, as far north as Hudson Bay, Canada, and as far south as Bakersfield, Calif.

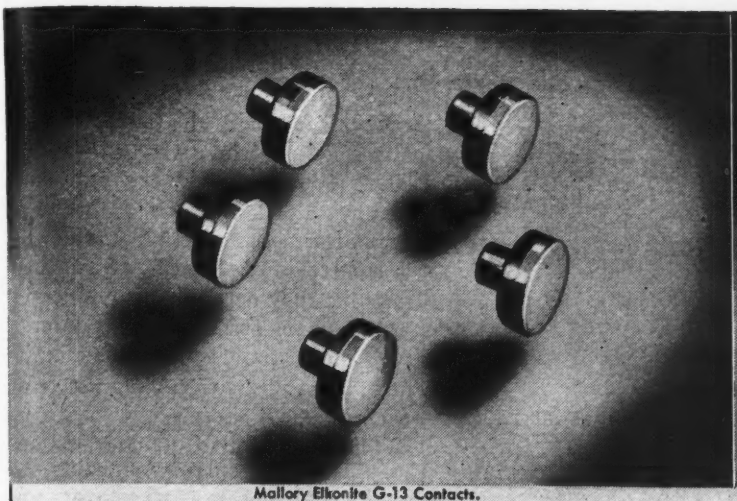
Hopper Control for Ore Crusher

AUTOMATIC CONTROL of ore crushers, to keep the machines operating continually at the peak load corresponding to maximum efficiency, is being done in the mining industry by two distinctly different types of electronic control units. In one installation, a microphone is positioned alongside the crusher, and connected to an amplifier and relay combination that controls the conveyor feeding ore into the machine. When the noise level drops to a point indicating that the crusher is running almost empty, the electronic ear detects the condition and calls for ore to be fed into the hopper.

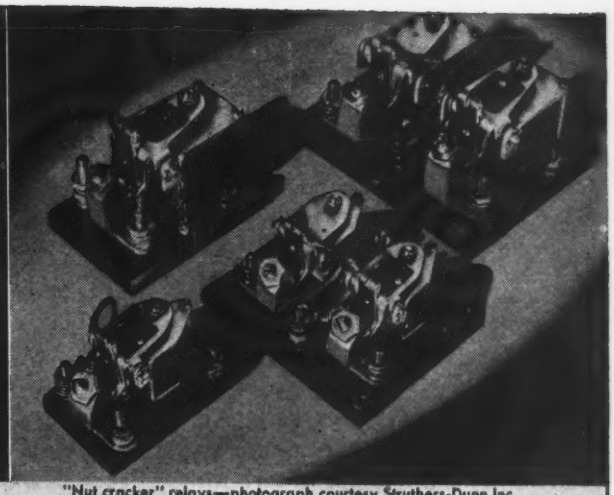
A second company uses a phototube arrangement to monitor the amount of electric power drawn by the electric motor which drives the crusher. This power consumption is high when the crusher is fully loaded, and drops as the machine empties. A light source and phototube are mounted over a wattmeter in such a way that the meter pointer interrupts the light beam when the power drops. The phototube feeds an amplifier-relay combination controlling the ore feed mechanism.

Temperature Control in Aircraft

ELECTRONIC ANTICIPATION of temperature requirements by automatic electronic cabin temperature control system has been in test service on several airlines and combat use on Army transport ships for some time. The complete sys-



Mallory Elkonite G-13 Contacts.



"Nut cracker" relays—photograph courtesy Struthers-Dunn Inc.

Small... But They Carry High Inrush Loads...

MALLORY ELECTRICAL CONTACTS

ELECTRICAL contacts for these "nut cracker" relays must be *small*—space is at a premium. They must be *tough*—to stand shock and vibration. Contacts must be *electrically rugged*—to carry as much as 1000 amperes inrush current at 24 volts DC.

Mallory metallurgists and contact engineers have helped the relay manufacturer to find exactly the right contact material to meet these rigorous requirements. Elkonite* G-13, developed by Mallory, efficiently carries the high current load with no welding or arcing.

Its toughness meets physical "specs" not only for impact strength but also for wear resistance—assuring long life.

Elkonite compound metals may be the answer if you're seeking materials for contacts or contact assemblies with unusual electrical and physical properties. With Elkonite G-13 and the related G-12 and G-14 materials, there is a sufficient range of properties to cover applications from relatively low current switches and relays up to heavy-duty circuit breakers.

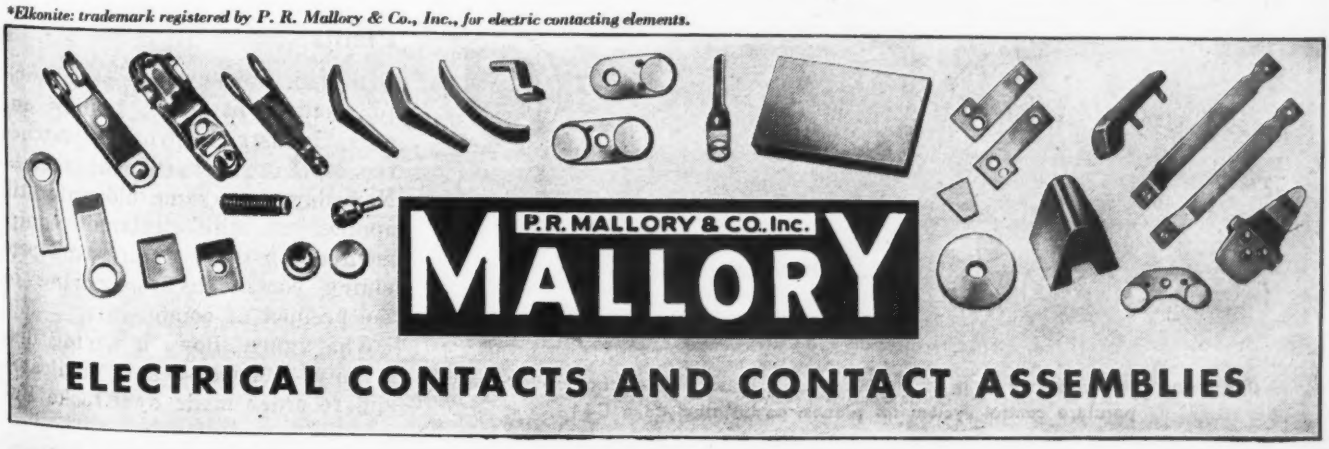
Consult experienced Mallory engineers on your contact and contact assembly problems. Often they can suggest complete assemblies that simplify your designs, save you fabricating time, and assure a more efficient product.

TYPICAL PHYSICAL PROPERTIES OF ELKONITE G-13

Grams per cc.	12.3
Lbs. per cu. in.	0.45
Conductivity %I.A.C.S.	55-60
Rockwell Hardness	70-80B
Tensile Strength psi	40,000
Cross Breaking Strength psi	115,000

P. R. MALLORY & CO., Inc., INDIANAPOLIS 6, INDIANA

*Elkonite: trademark registered by P. R. Mallory & Co., Inc., for electric contacting elements.

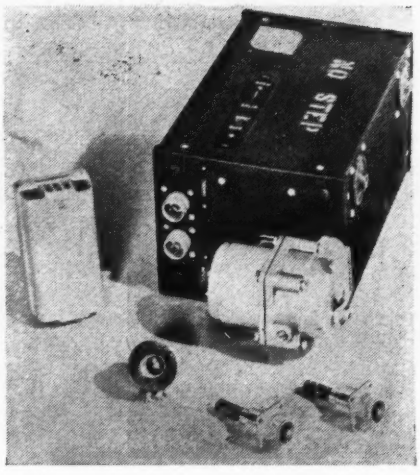


tem is shown in the drawing as developed by Minneapolis-Honeywell Regulator Company for the C-54.

Numbers (1) and (5) in the drawing are safety switches and valves which automatically cut off the flow of gasoline to the heaters if the fuel line breaks. At (2) is an air ram switch which automatically guards against operation of the heaters until sufficient forward speed is obtained to drive enough air over the heaters for adequate combustion. Numbers (3) and (8) are outside air compensators which actually turn the aircraft heaters on before a need for heat is detected within the cabin. At (4) is a control switch, installed in the cockpit, which selects the temperatures desired. Number (6) is an amplifier, which can be installed anywhere in the plane, and (7) is a cabinstat, installed in the space to be heated.

The new control system is a package unit weighing slightly under eight pounds, and is designed to hold automatically any cabin temperature selected by the pilot. To passengers, this means comfortable conditions under all kinds of flying weather, and to pilots and stewards it means an end to passenger complaints and the nuisance of constantly making adjustments of manual controls.

The new control system is connected to the master control switch in the cockpit and is automatically turned on when the pilot starts the engines. Unless heat is required immediately, the heating system remains inoperative until outside temperatures fall to a point requiring the addition of heat for passenger comfort. At this point, the heating system starts delivering heat to the cabin in the exact amounts needed to maintain the pre-selected temperature — usually 70 degrees.

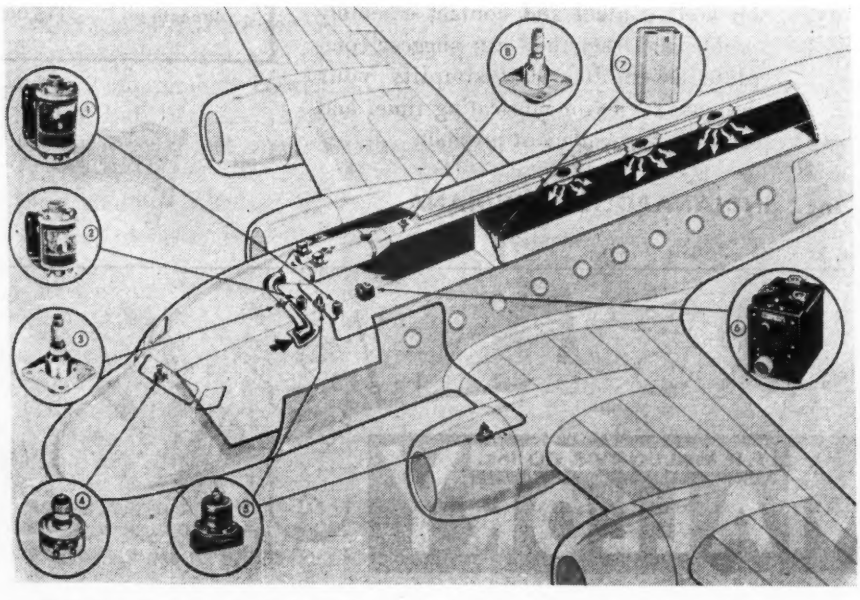


Units of the temperature control system. The electronic amplifier and infinite position motor which connects to the dampers of the plane's heaters are in the large cabinet. At left is the cabinstat, and at lower right are the outside air compensators which sense temperature changes and signal the amplifier that controls the motor delivering heat into the cabin

The system includes an outside air compensator, which is a small coil of wire installed in the duct bringing outside air into the plane's heaters. Temperature fluctuations change the electrical resistance of the wire and this change is measured through electronic tubes. When the tubes learn from the coil that the outside air is colder or warmer, as the case may be, they actuate a motor which opens or closes a mixing damper and thus proportions the amounts of outside air with heated air from the plane's heaters.

The system also includes a thermostat in the cabin which interprets temperatures and notifies the tubes which, getting signals from both coils, position the mixing damper to maintain the selected inside temperature. The latter is determined by a small dial mounted in the cockpit.

If a plane takes off while ground temperatures are at 70 degrees, no cabin heat is required, but as it climbs, outside temperatures usually drop. The outside compensator notices this drop immediately and tells the tubes which, in turn, start delivery of heat to the cabin. Passengers are not conscious of the outside change, however, because of the reservoir of heat in the cabin. Before this heat is lost to the outside, making the passengers uncomfortable, heat comes into the cabin in the exact proportion needed to maintain a constant and comfortable temperature. The reverse is true when the plane moves into warmer temperatures, because while the inside cabinstat calls for heat, the outside coil knows that less heat will be required and so less heat is delivered.



Illustrating the location of units of the Minneapolis-Honeywell electronic cabin temperature control system for planes, as installed on a C-54

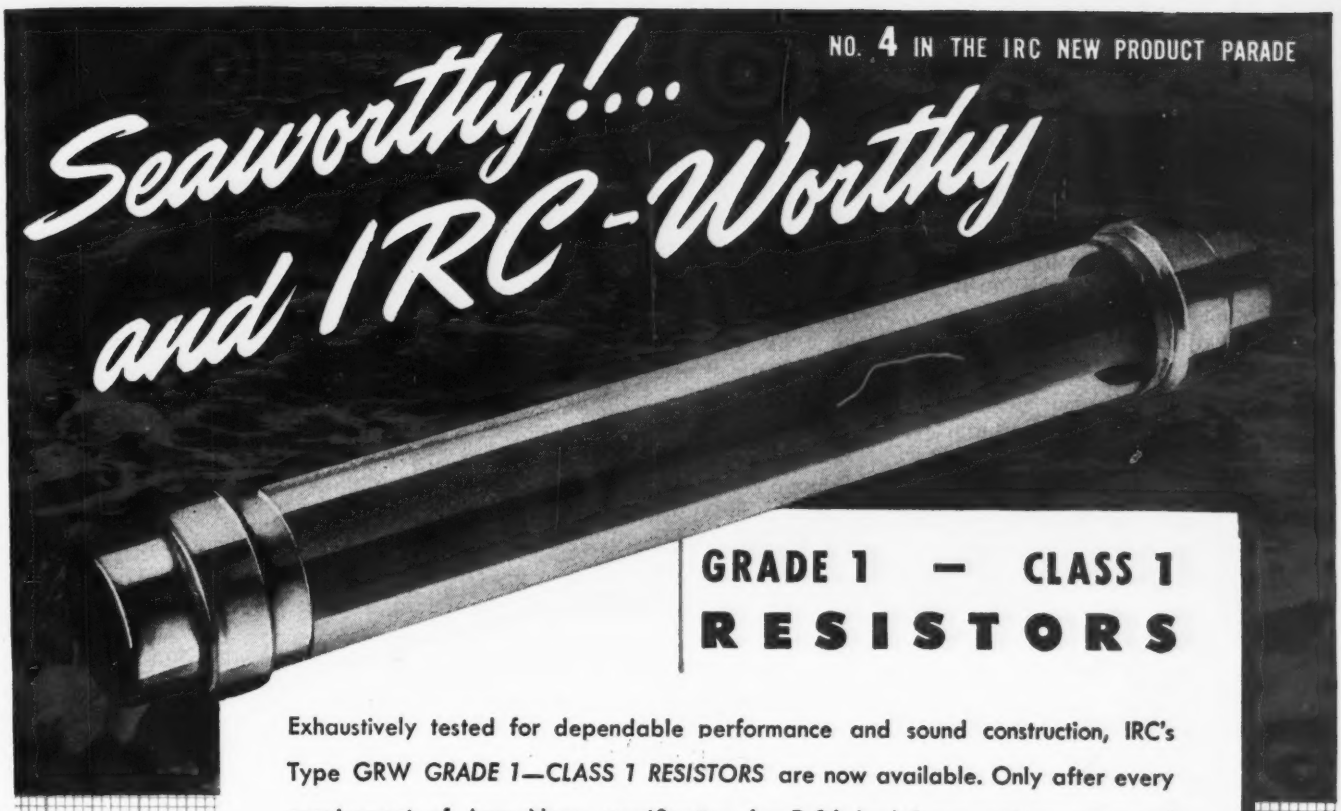
Smoke Density Indicator and Recorder for Industrial Plants

OLD TIME FACTORY men responsible for control of kilns, boilers and other industrial furnaces watched the stack to get efficient results. Nowadays, the same old rule still applies but with electronic equipment doing the watching and providing continuous monitoring of the product of combustion.

The figure shows a wiring diagram of a smoke-density indicator and recorder made by Brooke En-

NO. 4 IN THE IRC NEW PRODUCT PARADE

Seaworthy!... and IRC-Worthy



GRADE 1 — CLASS 1 RESISTORS

Exhaustively tested for dependable performance and sound construction, IRC's Type GRW *GRADE 1—CLASS 1 RESISTORS* are now available. Only after every requirement of Army-Navy specification Jan-R-26 had been met or surpassed would our Engineering Department approve this product for the applications for which it is designed.

Resistant to salt water immersion following thermal shock, they are capable of continuous efficient operation at a total temperature of 275° C. (ambient plus rise).

Made in 7 standard sizes with power ratings from 15 to 140 watts and resistance ranges of from 0.1 to 46000 ohms, the GRW's are enclosed in special heat-treated glass for optimum strength. Non-corrosive ferrules are hermetically sealed to the tube with pure lead. Nickel alloy leads pass through the centering devices and are welded to the outer ferrule cups. All resistors are *space wound.*

These IRC GRADE 1—CLASS 1's are engineered to "take it" far beyond normal requirements and can stand transverse loads as high as 100 pounds without failure or damage of any kind.

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FIXED & VARIABLE RESISTORS

Write today for special Engineering Bulletin containing dimension drawings, temperature rise and de-rating curves as well as other technical data.

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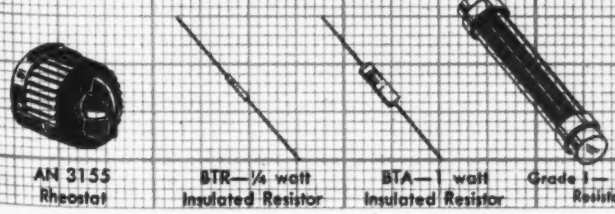
IRC makes more types of resistance units, in more shapes, for more applications than any other manufacturer in the world.



AN 3155 Rheostat | BTR—½ watt Insulated Resistor | BTA—1 watt Insulated Resistor | Grade 1— Class 1 Resistors

gineering Co. of Philadelphia. In this equipment, the eye box is installed at the point of observation in the stack and contains a double diode tube E, a double triode E_1 and a phototube P. In the control panel unit there are two thyratron tubes E_2 and E_3, a double diode E_4, and two signal lights, a red one R and an amber one A.

Control of the equipment centers in two switches, one for the light source and one for the electric eye. Assume both the light and the eye switches closed. Transformer T_1 supplies about 5 amp at 6-v to the lamp for the light beam across the gas stream to the phototube. Resistor R_1 permits adjusting the light beam to suit the gas density where the equipment is installed.

Operation

A tap taken between resistors R_4 and R_5 puts a negative potential on grid G_1 of tube E_1. With normal conditions in the stack, potentials on grids G and G_1 are equal. Tube E also charges capacitors C and C_1 to the polarity shown.

Assume that polarity of the line reverses to that indicated. With this line polarity, rectifying tube E becomes inactive because its anodes are now negative. However, capacitors C and C_1 were charged on the previous half cycle. Capacitor C discharges through tube P and resistor R_2 to maintain grid G negative. Capacitor C_1 discharges through resistors R_4 and R_5 to maintain a negative potential on grid G_1 of tube E_1.

A voltage drop across resistor R_7 puts a negative potential on grid G_2 of tube E_2, through part of resistor R_8 and resistor R_{10} and also through the left-hand half of T_3 transformer secondary, resistors R_{11} and R_{10}. A negative potential is applied in the same way to tube E_4 through a similar circuit. Tubes E_2 and E_3 are inactive during this half of the cycle because their anodes are made negative through lamps R and A. For the same reason, tube E_4 is inactive during the next half of the cycle, but capacitor C_2 was charged on the half cycle just considered and it discharges through resistor R_8 to maintain the grids of tubes E_2 and E_3 negative.

With normal gas conditions in the stack, the pointer of the indicating-meter M takes a vertical position. Currents flowing in the two halves of transformer T_3 are in opposite directions and when these currents are equal, as with normal gas conditions, they neutralize each other so that they do not produce a flux to energize the secondary winding. Under these conditions, tube E_4 impresses a negative potential on the grids of tubes E_2 and E_3 of a value that just prevents them firing.

Heavy Smoke

Assume that the stack gases darken, then less light will reach photoelectric tube P and less current will pass through resistor R_2, causing a reduction in negative potential on grid G. This lets more current flow to the left-hand anode than to the right-hand one, which in turn permits more current to flow in the right-hand side of transformer T_3 primary than in its left-hand side. As a result, a voltage is induced in the secondary of this transformer that makes the grid of tube E_2 less negative and that of tube E_4 more negative, and tube E_2 fires to light red lamp R.

When terminal G becomes negative, more current also flows through indicator M to deflect its needle to the left of midposition and show the amount stack gases have darkened.

If the stack gases become more clear than normal, showing the presence of too much excess air, then current flow through the phototube increases. This increases the potential on grid G and reduces current flow through the right-hand part of transformer T_3 primary. This permits the left-hand end of the primary to establish the secondary potential which is opposite to that for gas more dense than normal. Now the grid of tube E_4 is made less negative and it fires to light amber lamp, A. Less current also flows through meter M and its pointer swings proportionally to the right to show the amount the stack gas is under color.

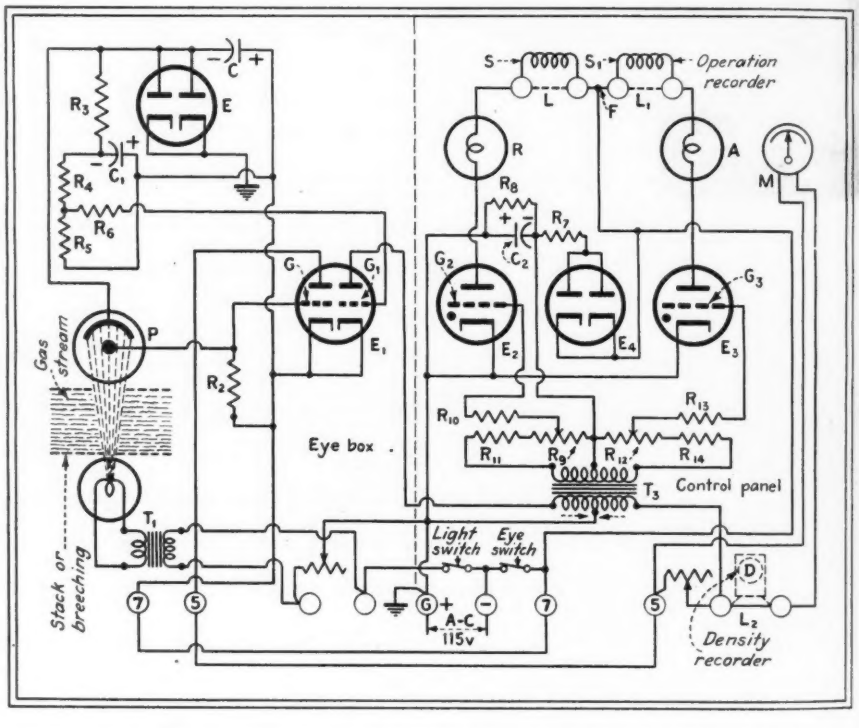


FIG. 1—Complete electronic circuit of a smoke density indicator. Recording equipment may be used with the unit to show the length of time the smoke is off-color or the density of the gases

Recording

Either one of two recorders may be used. When an operation recorder is used, links L and L_1 are removed, and then the lamp circuits are through the recorder's coils, S and S_1. When the red lamp lights, coil S is energized. Lighting the amber lamp makes coil S_1 active. This recorder shows only that the stack gas is off color and for how

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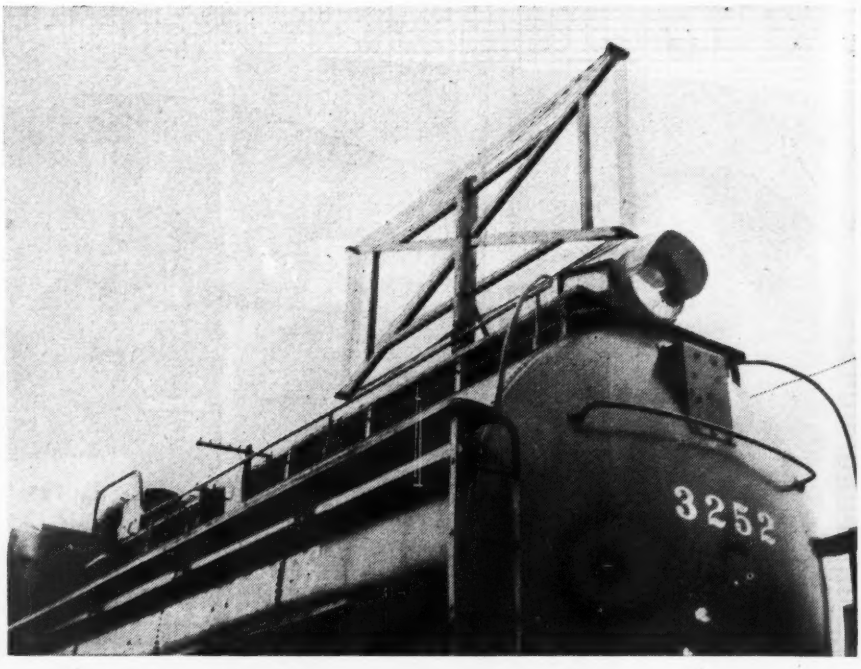
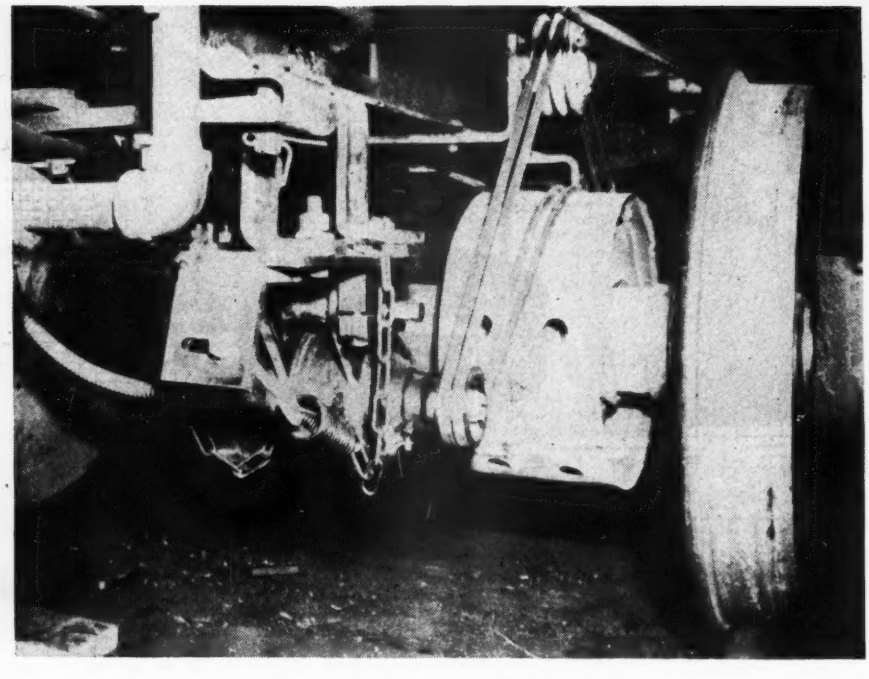
long it is off color, but does not record the density of the gas. To use a density recorder, D, remove link L_s to put D and M in series. D records the amount the stack gas is off color and in what direction, that is, it records the amount needle of meter M is deflected, and the direction of its movement.



RIGHT—The loop antenna for induction to the wayside wires is mounted on the locomotive

BELOW—Power for the electronic equipment used by Aireon in caboose installations is supplied by a 24-volt battery. Charging is accomplished by a generator belt-driven from the caboose wheel



Carrier Current versus Space Radio for Railroads

AS A RESULT of a survey of electronic equipment used by various railroads, engineers of Aireon Manufacturing Company have found that the induction type of carrier current communication may not always be applicable for all aspects of railroad radio. The sole limitation, when one exists, is in the head to rear end circuit. This is due to the fact that two magnetic coupling links are involved, i.e., rear end to wayside wires and wayside wires to head end. A loss factor of about 20 db is involved in each of these magnetic jumps.

Failure of the head to rear end circuit to operate at full efficiency is due to one of the following reasons:

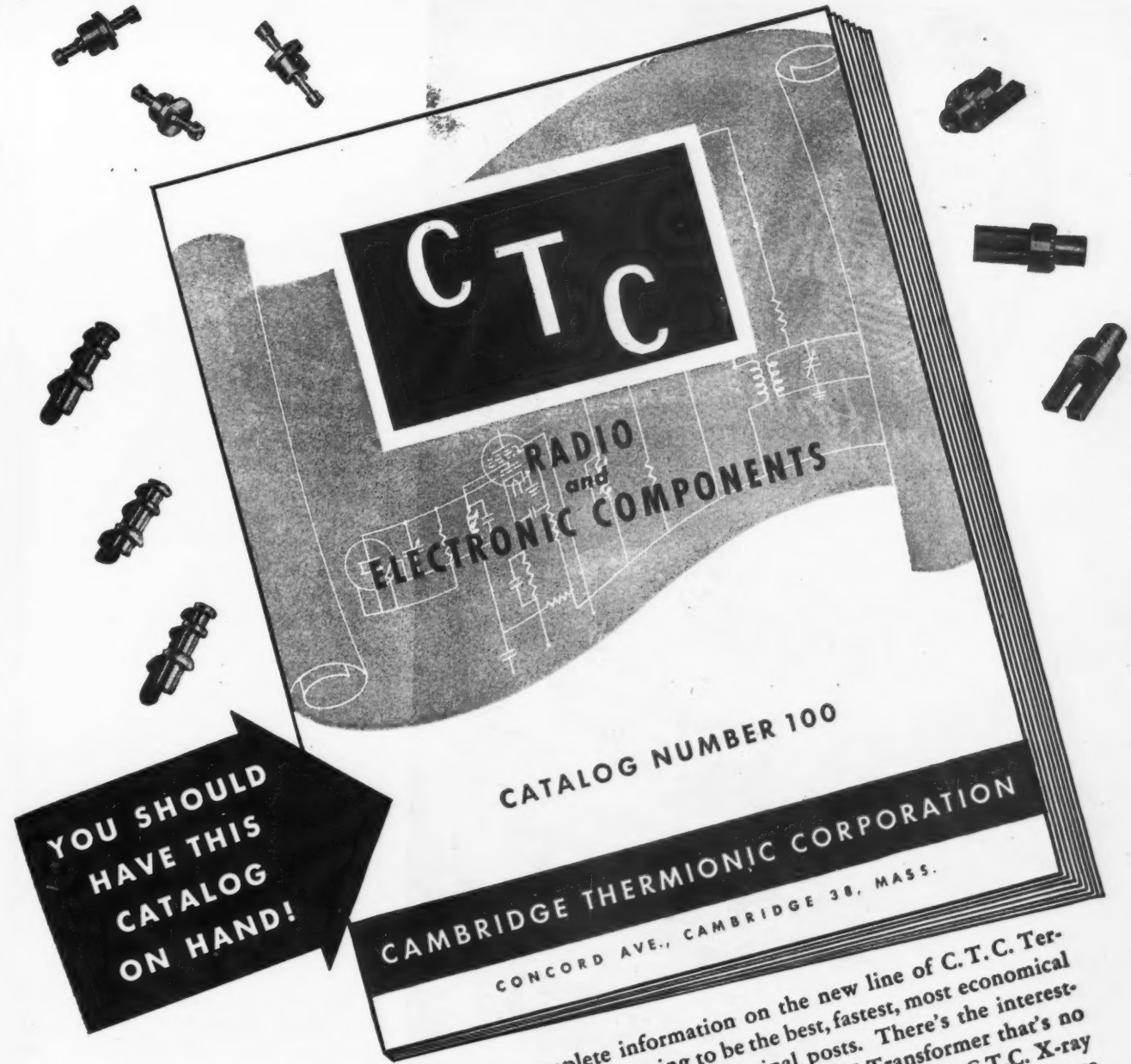
1. The non-existence of wayside wires, and inability to provide such facilities due to physical limitations.
2. Spacing between wayside wires and track too great for practical induction communication, i.e., spacing in excess of 200 feet.
3. Wayside wires contained in lead sheath cables for considerable distances.

In general, corrections can be made by adding a single wire along the right-of-way, to augment all of the possible discontinuities. If this is found impractical, it is necessary to consider the use of 100 percent space radio or a combination of induction type and radio.

Use for Each

It is generally agreed that the induction system is the most practical for communication between wayside stations and between a wayside station and train. The use of space radio on the main-line can be confined to end-to-end communication, except the possibility of using space radio for wayside contacts about certain sections of track where wire facilities are not suitable. The only possible alternative to the induction system for wayside operation is a vhf relay link. This has serious disadvantages, as follows:

1. The frequencies which will probably be allotted to this service are so high as to require relatively new engineering approaches.
2. Because of the line of sight limitation of transmission range, expensive towers, power lines, etc., will be required.
3. The cost per mile is many times in excess of the cost of an induction



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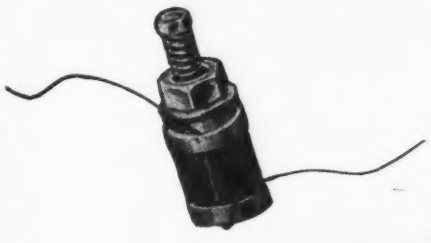
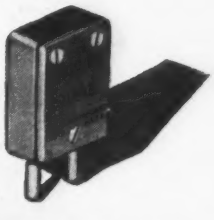
You may find the information in the Catalog very useful to you in connection with present or projected components. Write for it today. Ask for C.T.C. Catalog Number 100. No obligation, of course.





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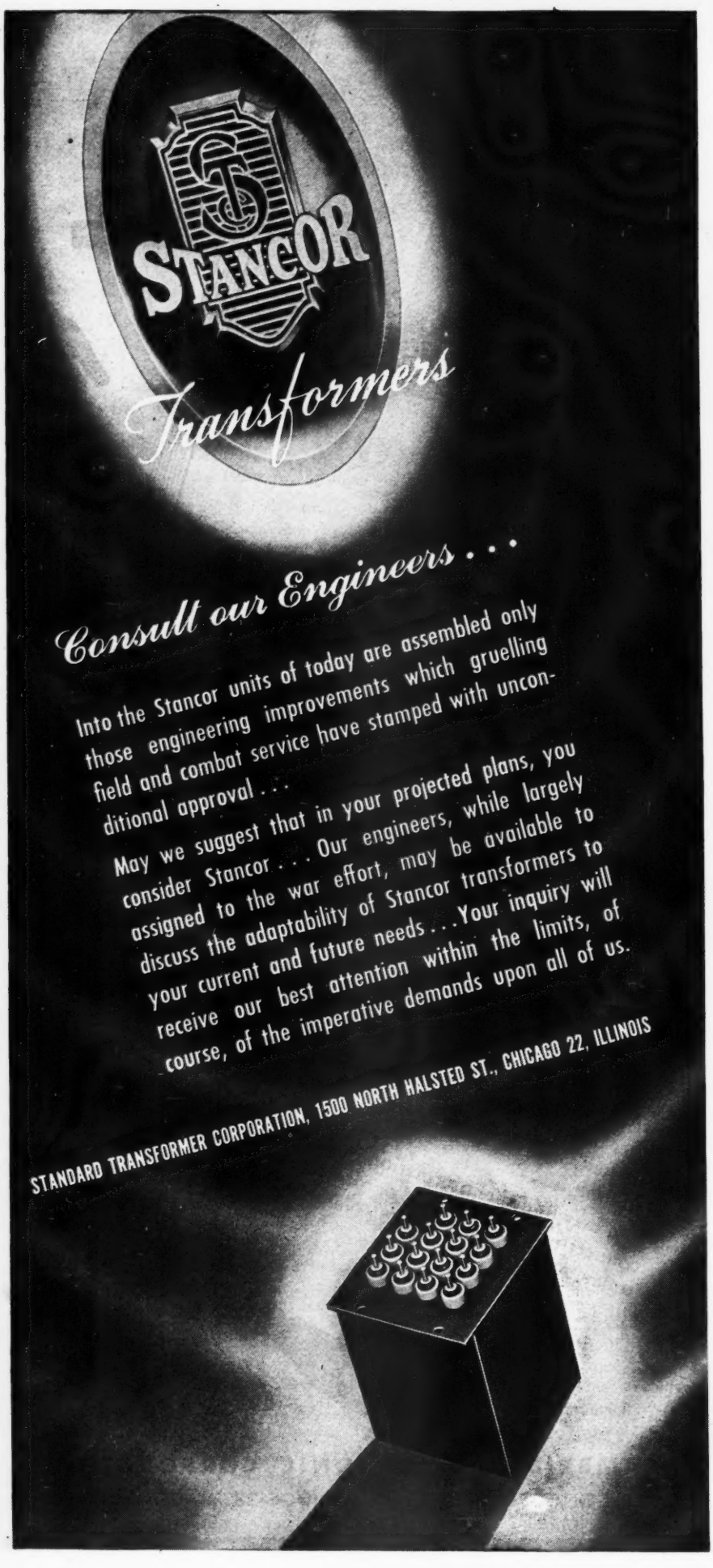
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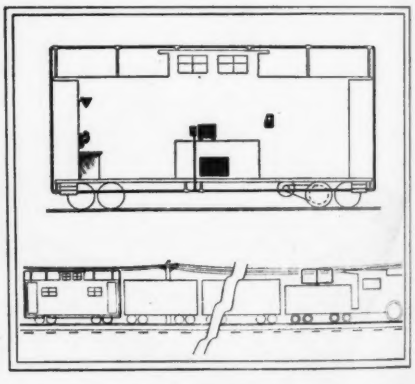
system performing the same services.

The following combination of carrier current and space radio systems is recommended by Aireon engineers in the event that wire line facilities are not within the limitations described heretofore:

1. Induction type carrier system for all wayside point-to-point and wayside to caboose communications.
2. Space radio for head to rear end circuits.
3. Space radio for use in yards and terminals.

Space radio communication would be employed during the switching operations in the yards and on road engines and cabooses while they are in the confines of the yard or terminal. After the departure of the train from the yard, the low-frequency carrier equipment would be employed as soon as the train entered the main-line, where wayside wire facilities are available. In most cases, these wayside wires would be at trackside before the train was out of the range of the vhf yard equipment thereby permitting 100 percent communication between the train crew with some yard or wayside office from terminal to train of the train's run.

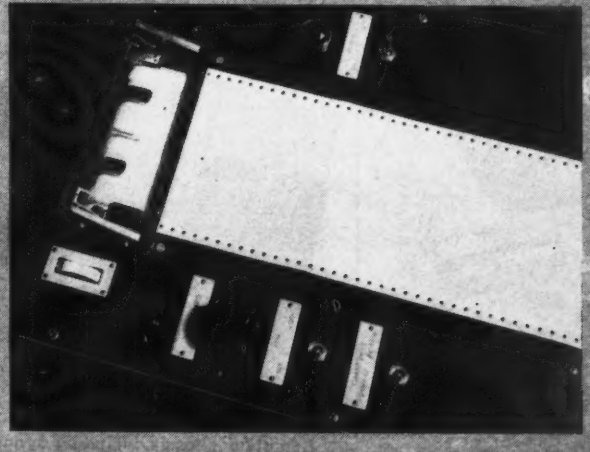


TOP—The loop antenna for an all-metal caboose (shown above by the heavy line) is mounted externally around the entire caboose and supported by stand-off insulators. The location of the other units is also shown

BOTTOM—Antenna installations on caboose and engine tender for induction to the wayside wires. On the Kansas City Southern, Aireon equipment is installed on 5 cabooses, 5 locomotives and 22 wayside stations

A typical wayside office installation of Aireon induction equipment

The attractive Ls housing of the Recordagage leaves all parts of the complex instrument readily accessible.



Top panel of the Recordagage. Panel is of black bakelite and is mounted directly to the Ls.

Beauty THAT'S MORE THAN SKIN DEEP

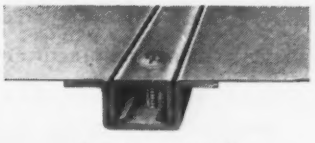
Electronically operated Recordagage is supported, protected, and attractively housed by its sturdy Ls cabinet

The Physicists Research Company, builders of the electronic displacement charting device called the Recordagage, chose Lindsay Structure for the housing for other advantages as well as for its attractiveness.

Equipment housed in sturdy Lindsay Structure is protected against dirt, moisture, and mechanical damage. The die-formed parts for Ls fit snugly together; Ls units, utilizing the principle of uniform tensioning, are rigid and vibration-proof.

The unique high strength-weight ratio of Lindsay Structure saves space and weight in any of its thousands of applications. No heavy, bulky diagonals, gussets, or struts are necessary. Quickly and easily assembled, this modern method of light metal construction requires no retooling, trimming, fitting, welding, or riveting for its erection.

Investigate the advantages of Ls when applied to your product. Write to **Lindsay and Lindsay, 222-D W. Adams St., Chicago 6, Ill.; to 60 E. 42nd St., New York 17, N. Y.; or to Lindsay Structure (Canada) Ltd., Dominion Square Bldg., Montreal.**



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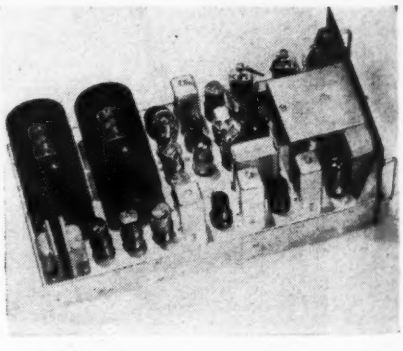
consists of a frequency-modulation transmitter and receiver combination designed to operate in the low-frequency portion of the spectrum (approximately 70 to 200 kc). The transmitter section comprises a stabilized oscillator, an audio amplifier and reactance tube, and a class-C power amplifier, whose output power may be coupled between one of the wayside telephone wires (and ground)—or between two wayside wires and ground in simplex fashion, through appropriate tuned filters. The power output of the transmitter as delivered to an average simplex line circuit is adjustable in six steps from approximately 0.1 to 5.0 watts. This adjustable feature provides a means of setting the power output to conform to a particular local circuit requirement.

Receiver

The f-m receiver contains two pretuned r-f amplifiers, a limiter and discriminator circuit, and an audio amplifier. To minimize interference from noise, special circuits have been incorporated to provide automatic noise squelch action without manual adjustment. This



Complete chassis, including dynamotors, of the f-m transmitter and receiver designed for operation on frequencies between 70 and 200 kc

squelch circuit provides practically complete noise-free reception for all anticipated values of received signal to noise ratio. Either the receiver or transmitter is in operation at one time, but not both. However, no common operating components or tubes are employed in the transmitter or receiver.

To facilitate remote control operation of the equipment (as for example, control over a considerable distance by means of a dispatcher's telephone circuit), a

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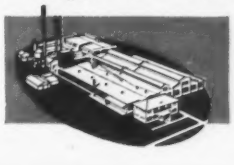

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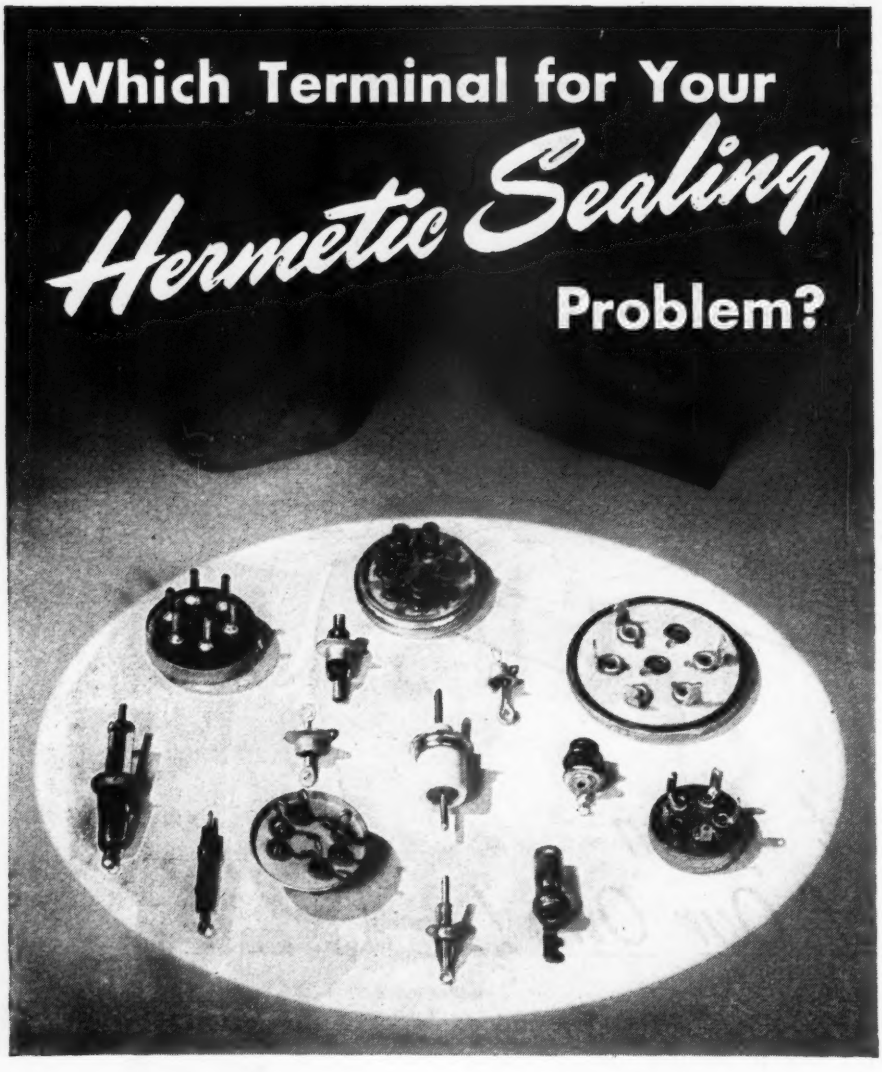

● To correctly seal transformers and filters it is highly important to select the right terminal for each particular design. Relationships between electrical and mechanical requirements, space limitations and overall specifications are all important in the achievement of good performance — every factor must be given careful and detailed consideration.

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voice-operated "vodas" is provided. This requires that the receiver and transmitter be interlocked electronically to permit operation on a talk-to-talk basis. No relays or mechanical switching devices are employed, all switching being done electronically.

Mobile Equipment

The equipment for use in either caboose or locomotive operates from a 24-volt d-c source, and requires 400 watts for periods of transmission, and 100 watts standby power for continuous operation of the receiver. The receiver circuit is similar to that in the wayside station.

The transmitter section employs a stabilized oscillator, an audio amplifier and reactance tube, and a class-C amplifier output stage which feeds 50 watts of carrier power to the loop antenna. The mobile equipment operates on a push-to-talk basis. While the handset is on the hook switch, all calls are received on the loudspeaker. During conversations, the earphone of the handset operates.

For locomotive installations, the unit is mounted either in the cab or in a weather-proof box on the deck of the tender. If mounted on the tender, it is remotely controlled from the cab. The remote control unit contains the hook switch for holding the handset, the audio volume control and the signal indicating lights, and is designed for mounting either in the locomotive or in the caboose.

Pickup Loop

In general, the loop antenna for the caboose varies with the type of car on which the equipment is to be used. For a wooden caboose with canvas roof, the loop can be installed inside the car. Such a loop, as operated at 175-kc carrier frequency, consists of 4 turns of wire wound in a vertical plane with dimensions equal to the inside height and length of the car. For cabooses employing wooden construction with steel reinforcing beams and a metal roof (or for all-steel cabooses), the loop antenna is installed externally and consists of approximately 4 turns of wire wound in a vertical plane completely surrounding the car and supported on top and bottom of the

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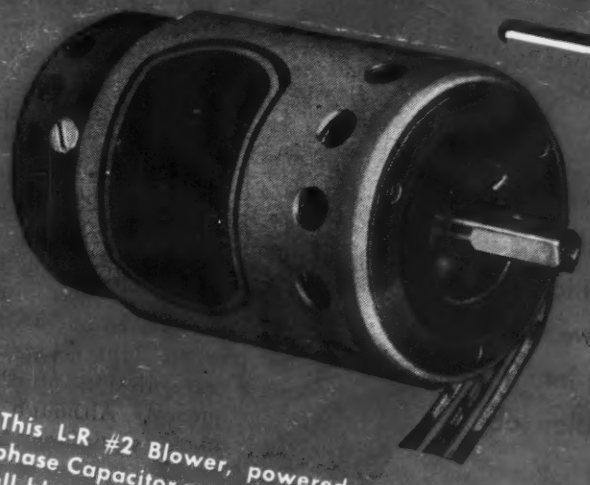
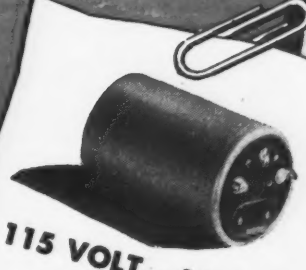


115 VOLT 400 CYCLE BLOWER

This L-R #2 Blower, powered with our J31A 1/100 H.P. single phase Capacitor motor measures 4 7/32" overall length, 3 3/4" overall blower diameter, 1 15/16" overall motor diameter and weighs 19½ ozs. Running at 7200 R.P.M., it circulates 22 cu. ft. per min. continuously. It is designed for use in ambient temperatures up to 80° C. Production facilities enable us to offer prompt deliveries on this equipment, which is outstanding in efficiency and air delivery for its small size and light weight.

NOTE: Type J31A and J49 motors are available for use in other applications. Write for information and performance data.



115 VOLT—60 CYCLE BLOWER

For same application as above but for operation on 60 cycles supplied at 3300 R.P.M. L-R No. 2 Blower, powered with our J49 capacitor motor, circulates 10 cu. ft. per min., continuous duty, with 9 watts input to motor.

J49 Dimensions:
Overall Length.....2 1/16"
Overall Diameter....1¾"
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car by suitable masts or brackets. In the case of locomotives, the loop antenna varies with the engine model. Most suitable positions are on the deck of the tender or in front of the smoke-box.

Optimum Performance

The only important limiting factor to the complete successful operation of this system is the distance between the track and the wayside wires. For frequencies between 150-200 kc, the equipment performs satisfactorily when the track to wayside wire separation does not exceed 150 feet as measured horizontally. Operating conditions are retained for this horizontal distance and for road conditions wherein the wayside wires are not more than 75 feet above or below the track level. Up to 100 percent in excess of these figures, the system will still perform creditably with satisfactory signal-to-noise ratio in the receiver. No modifications of wayside wires are required except in certain rare instances where telephone drops may have to be isolated for that particular carrier frequency. This is accomplished by insertion of a tuned circuit at a junction point.

Where no wayside wires are sufficiently close, a simple single wire line can be mounted on fence posts or on light construction poles for transmission of the carrier frequency. Although the carrier-frequency signal may be applied by the wayside station to only one pair of a number of overhead wires, the signal is carried by all the wires due to capacitive and inductive coupling among them. Consequently, if wires are broken, even though they be the wires to which the signal was originally applied, it is necessary only to have one wire available for continuation of the communication system. Wires can be down for several pole lengths before the influence of the break is noticed.

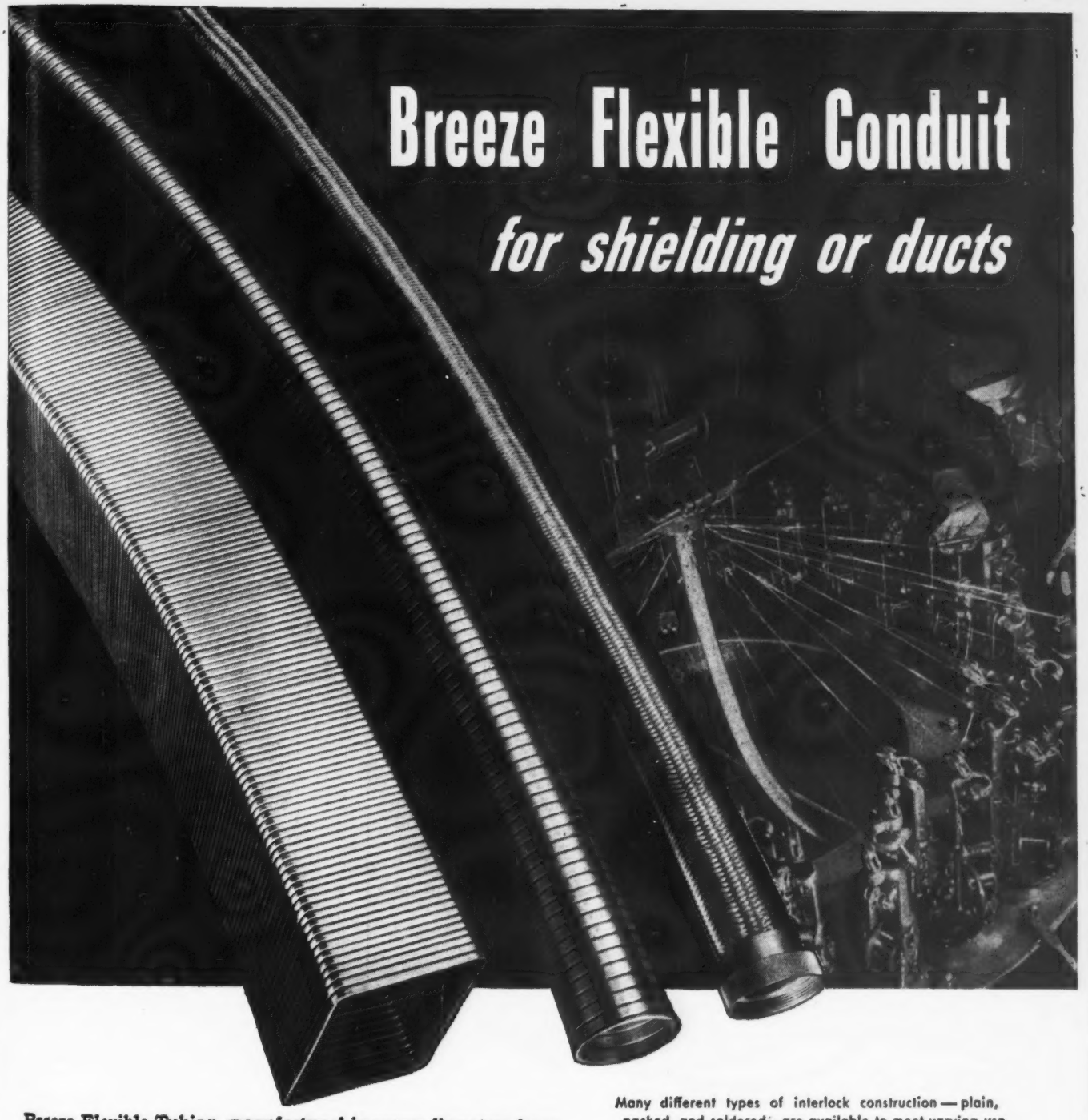
• • •

Electronic Inspection of Magnetic Materials

TESTING OF RAILROAD rails has been done in the U.S.S.R. by a defectoscope, an electromagnetic device that contains ferro-magnetic plates. These plates close a transmitter

Breeze Flexible Conduit

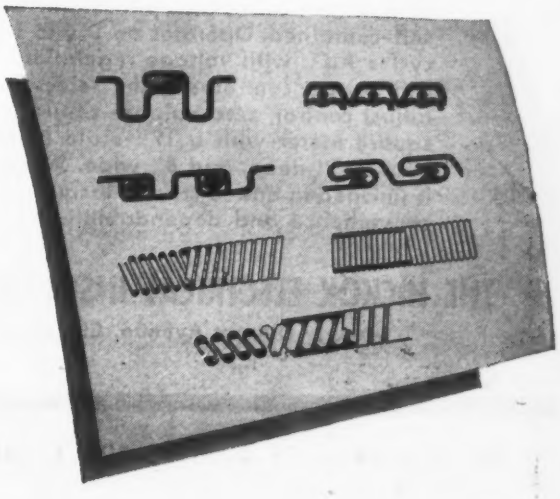
for shielding or ducts



Breeze Flexible Tubing, manufactured in many diameters from a wide variety of metals, is used as ventilation and exhaust ducting in industrial, aircraft, marine and automotive applications. The same basic tubing, with the addition of a braided metal covering, becomes light-weight shielding conduit, used extensively for shielding ignition systems and any electrical circuit to insure dependable radio communication.

Manufactured from a continuous strip of metal, Breeze Flexible Tubing and Conduit can be furnished cut to length, with necessary end-fittings for any conduit installation.

Many different types of interlock construction — plain, packed, and soldered—are available to meet varying use requirements. A few of these are illustrated below.



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Provides for electronic A.C. and D.C. Voltage measurement with extremely high input impedance. Provides an electronic ohmmeter for resistance measurement from .1 of one ohm to 1,000 megohms. Also provides a milliampere meter giving 5 ranges of measurement to one ampere.

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Meter cannot be damaged from over-voltage on any range due to the electronic circuit arrangement. Built with 4 tubes and pilot light. Power supply is self-contained. Operates on 110 to 120 volts, 50-60 cycles A.C., with voltage regulation included. Special range control switch, selector switch, ohms adjust control, zero balance control and a large 5" square meter with a 17" scale length. Size 10½" high, 7½" deep, and 8" wide. Weighs 14 lbs. and is finished in baked crackle lacquer. It's a honey for convenience and dependability.

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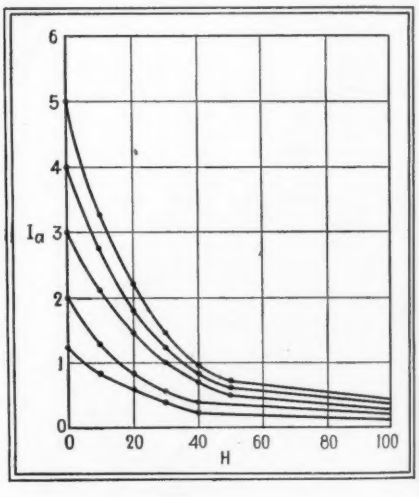
THE STANDARD OF QUALITY FOR A THIRD OF A CENTURY

circuit when acted upon by the magnetic dispersion field over the flaw. Operating speed of this arrangement was low, however, and a faster detector was sought that would shorten the time that a section of track was out of use and allow testing at working speeds so as to simulate operating conditions of stress, etc.

An electronic detector has been developed that permits testing at speeds of 10-25 kilometers per hour, depending on the profile of the track.

This new inertialess detector is a thermionic tube with a specially shaped anode. This is in the form of a cylinder with its concave surface pointing downward to the bottom of the tube, and with the filament in the center of the semicylinder. The usual top of the tube



Four curves plotted at different anode voltages for a node current versus H, the magnetic intensity

is thus the bottom and is made flat to allow the heating wire to approach as closely as possible to the glass without causing injury. To increase sensitivity, the tube is connected to an electronic amplifier.

In the testing technique, the rail is subjected to a permanent magnet, an electro-magnet, or a powerful current. The tube, enclosed in a special protective frame, is placed on the part to be tested perpendicular to the filament.

Theory of Operation

Before the tube is placed on the test piece, the electrons emitted by the cathode are distributed uniformly over the whole interior surface of the anode but the presence

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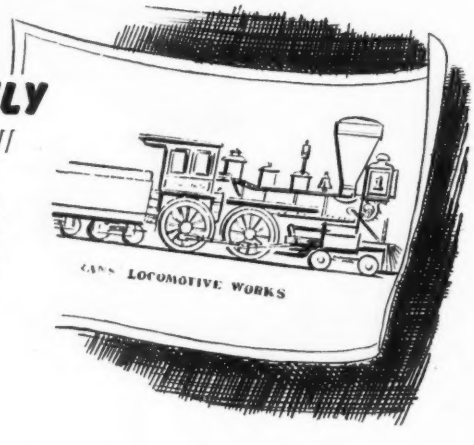

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of a general field of dispersion will cause a redistribution of the electron flow towards the lines of force of the magnetic field. This brings about an increase in the internal resistance of the tube and a change in the anode current. By selecting suitable loading resistance it is possible to give the first tube in the amplifier a standard grid bias which will compensate the disturbance and restore the original anode current. It is therefore possible to adjust the detector so that it will not react when it passes over sound parts.

If the tube passes over a flaw, a local field of dispersion is created which sharply deflects the electron flow by shortening the path from the cathode to the anode. This produces a drop in the grid voltage of the first amplifier tube and so alters its anode current. These variations are either used to operate a relay and an alarm system, or are presented on a cathode-ray oscilloscope. The curves show the dependence of the anode current on the intensity field H at different anode voltages.

Results

Tests made on rails with various types of flaws have shown that those with a cross section of the order of 0.1 percent of the total cross-section may easily be detected and it was found that the indications do not depend on the speed of the tube over the rail, a

• • •

RADIO IN BLIMP

Communications equipment in Navy blimp is operated by John H. Scott, Aviation Radioman 3C, to contact other members of an air-sea rescue task unit

great advantage over the existing methods using ferro-magnetic plates or powders.

This defectoscope is capable of wide variations in sensitivity. Increasing the anode voltage decreases the sensitivity because weak dispersion fields of abnormal shape will not have time to affect the electron flow. On the other hand, reducing the anode voltage and increasing the filament temperature results in an increase of sensitivity.

For the lower testing speeds, it was found that a sensitive relay and a paper-tape type of recorder gave good results, but for the highest speeds a c-r oscilloscope working in conjunction with photographic paper was found to be better.

• • •

Power Supplies for Photoelectric Controls

By DANIEL SCHULMAN

IN MANY INDUSTRIAL applications of phototubes and photocells, some consideration must be given to undesirable modulation of the light source by the lamp current. To eliminate this condition, one method is to excite the lamp used as the light source by means of power from an a-f or r-f oscillator instead of from the usual 60-cycle supply line. In certain industrial control applications, this is done so that response is had by the control equipment to only one lamp in a group, the proper frequency being selected by a band-pass filter in the phototube amplifier.

These problems are similar to those that exist in facsimile transmission and sound motion pictures. In these fields, self-excited oscillators or master-oscillator power-amplifiers are commonly used to supply the lamp with current. The frequency of excitation may range from 300 cycles per second up into the radio-frequency region. The particular frequency selected will be dependent upon the inertia characteristics of the filament. As a rule, the higher the power of the exciter lamp, the greater is the inertia of the filament, and the lower is the frequency required for minimum modulation.

In Fig. 1 is shown the circuit of a self-excited oscillator that has

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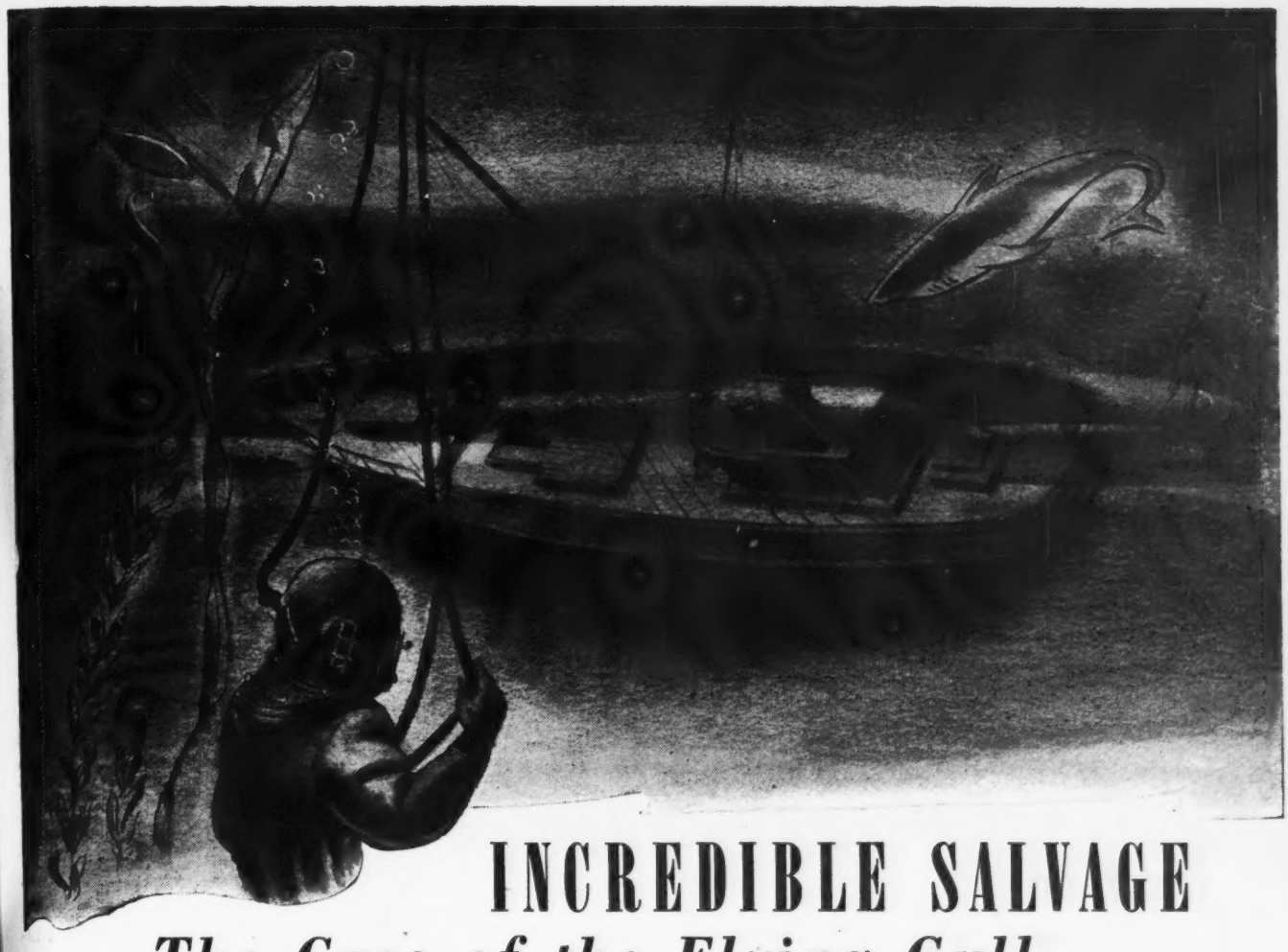

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Salvage operations were started. Later in 1942, when The Flying Gull was in the dock and her electrical equipment ripped out, an amazing thing occurred. George Long, of The Harris Salvage and Drydock Company of Galveston, put the Thermador transformer equipment on a shelf in the sunshine—mentally assigning it to the scrap metal drive. Three days later, out of curiosity, he hooked the transformers onto a testing bench and flipped on the current. To his amazement, they still showed signs of life. He then ran standard tests. To his further astonishment, all twelve of the transformers were not only working—they were working perfectly.

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been used to excite a 6-watt lamp in a 16-mm sound projector. This circuit is designed to operate in the supersonic frequencies, desirable for two reasons. Lower audio frequencies would have a tendency to be picked up by induction into the high-impedance input of the first audio stage in the high gain amplifier. Radio frequencies of a higher order would have a tendency to radiate, and also reduce the efficiency of the oscillator. Efficiency

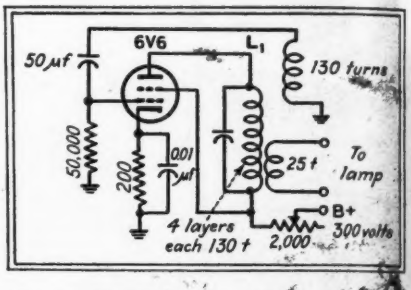

Fig. 1—Circuit of self-excited oscillator supplying current to a 6-watt exciter lamp

is quite important since excessive plate current would call for a larger and more expensive power transformer.

In addition to the grid leak bias there is shown a self-biasing resistor. Should the exciter lamp burn out, the tube might cease to oscillate and the cathode resistor would bias the grid and hold the plate current down to a normal value. This is necessary so that the tube will not be damaged. The 0.01-μf capacitor places the cathode effectively at ground potential. The variable rheostat in the plate circuit will vary the brilliance of the lamp.

Coil Data

Inductor L_1 is of the air-core type wound on three-inch tubing with ⅜-in. inner diameter. There are three windings, a primary coil of four layers, 130 turns each of No. 28 wire; a feedback coil of 130 turns of No. 28 wire, and, a lamp winding of 25 turns of No. 18 enamel wire. One side of the lamp winding may be grounded. There is no heat generated in this coil.

With this type of oscillator, a high-quality sound amplifier may be employed, since no attenuation of the low-frequency response is necessary. An objectionable feature of this circuit is that the brilliance

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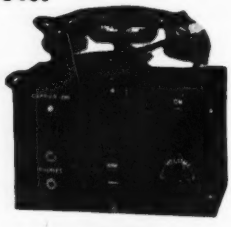

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of the lamp changes with line voltage variations.

Figure 2 shows a phase neutralization method that may be used when 60-cycle modulation is encountered. Resistor network R_1 and R_2 impress a 60-cycle voltage equal in amplitude and 180 deg out of phase with the signal voltage, so that the effective potential measured from point A to ground will equal zero. The alternating poten-

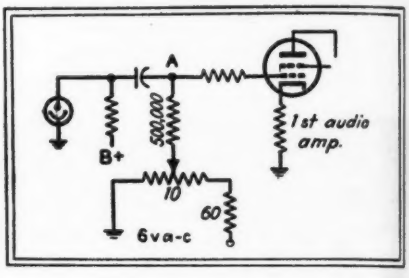

Fig. 2—Balancing arrangement for overcoming the effect of 60-cycle modulation of a light beam

tial must be properly phased in the R_1 and R_2 network to give proper cancelation. Reversing the secondary or primary leads of the power transformer will give the proper phase. This system has the advantage of being economical but requires frequent adjustment and also affects the frequency response.

Filter Circuit

Figure 3 shows a high-pass filter arrangement that is commonly used. Attenuation of the low frequencies will start at 350 cycles with the values indicated, and at 60 cycles the hum modulation is at an acceptable level. It is desirable to have the hum level 45 decibels

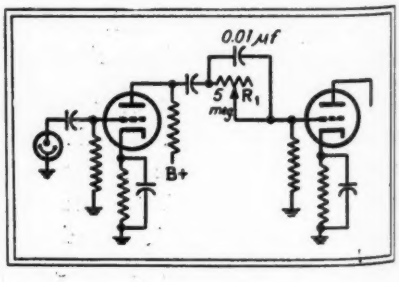

Fig. 3—This high-pass filter circuit satisfactorily attenuates frequencies below 350 cycles

below the signal level in 16-mm sound projectors.

In facsimile transmission, special problems are involved. Normally, the picture is placed on a revolving

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drum and the small area that is illuminated by the exciter lamp is focused by an optical arrangement to the sensitized medium of a phototube. Variable intensities of light are reflected from the exposed area depending upon the degree of white in the picture. Voltage peaks of 60 cycles would correspond to greater lamp voltages at certain phases of the cycle. These peaks of voltage cause corresponding peaks of illumination which show up as definite patterns of wavy lines. This objection can be removed by having a controlled high audio-frequency voltage feeding the exciter lamp.

Use of Class B Amplifier

Figure 4 shows a satisfactory circuit that overcomes these difficulties. The lamp is excited from a low-voltage secondary winding of the output transformer T_2. An

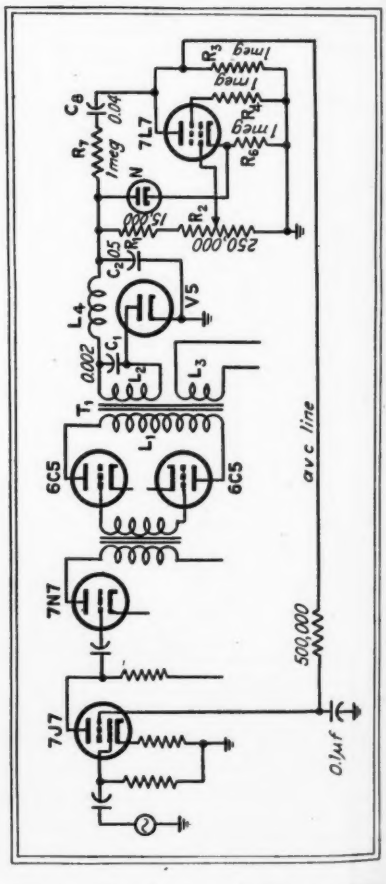

Fig. 4—Circuit of controlled amplifier for supplying current to an exciter lamp in a photoelectric control system. Both input voltage and line voltage variations are corrected by the avc arrangement to maintain a constant output

audio signal is fed into the input of the first audio amplifier tube. This is resistance coupled into a driver tube. Since efficiency is desirable and only a single frequency is

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power output. Suppose a 310-volt potential instead of 300 exists across R_1 and R_2. Since the drop across the neon bulb is constant at 60 volts, there will exist 250 volts between cathode and ground. The setting of R_2 places the divider network in a 5-to-1 ratio of resistance since it was set in a voltage ratio of 250 to 50 volts. The potential existing from grid to ground will equal 5/6 of 310 or 258.3 volts. This is 1.7 volts more positive on the grid than the original circuit potential. The 7L7 will then draw more current and cause a greater voltage drop across R_3, which will in turn place a more negative bias on the 7J7. Reduction and stabilization of the amplifier output is then accomplished and the output is restored to 300 volts across R_1 and R_2. Maintaining this output constant will regulate the exciter lamp voltage since the two circuits are coupled to the same primary.

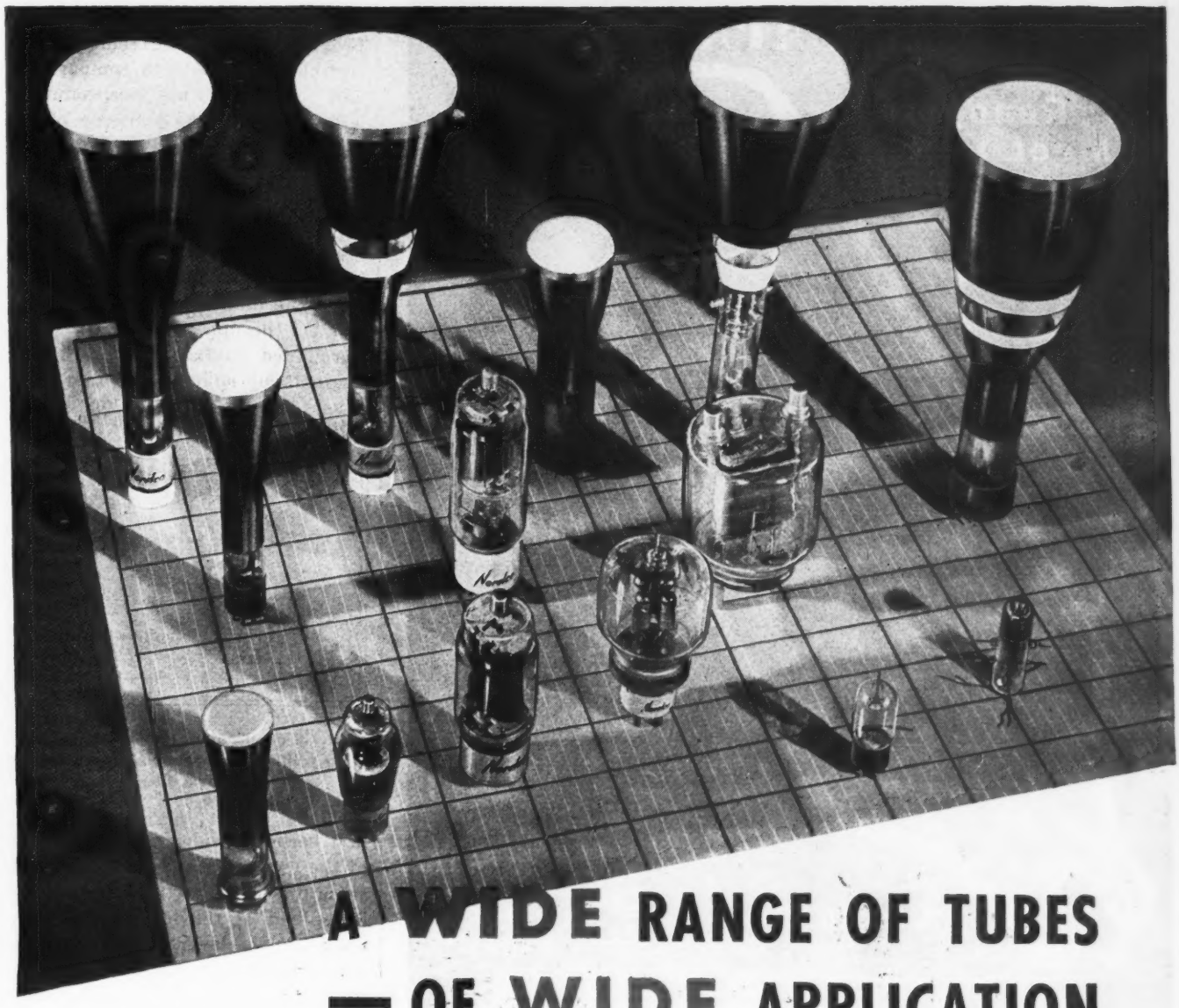
Instead of 310 volts appearing across R_1 and R_2, an instantaneous rise to 400 volts may develop. Then the circuit potentials will equal negative 340 from cathode to ground, 340 volts plate and screen supply, and 5/6 of 400 or negative 333 volts to ground at the grid. A positive potential of 7 volts will then exist on the grid of the 7L7. This is 17 volts more than the original setting. The circuit will then have a tendency to hunt, with a consequential time delay that may burn out the exciter lamp before regulation takes hold. To prevent this, R_7 and C_8 are incorporated. Resistor R_7 is selected to give optimum phase angle to prevent regeneration.

This circuit will regulate within 1/20 of a volt on signal variations of 3 to 10 volts, and line voltage variations between 90 and 130 volts. The frequency may range from 300 to 3000 cycles per second on the signal grid.

• • •

Electronic Width-Gage for Strip Materials

THE CIRCUIT of a vacuum-tube gage for measuring the width of movie film is shown in the illustration. With minor changes, the unit can be adopted to give width or thickness measurements for many other



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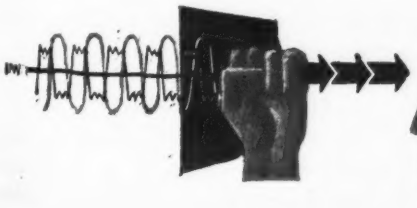

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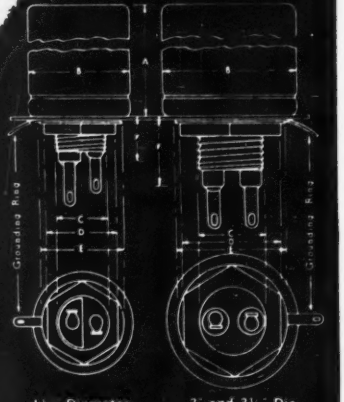

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6EC300	3.0	600	4½	1½	¾x16thd	1	1¼	⅝
6EC400	4.0	600	4½	1½	¾x16thd	1	1¼	⅝
6EC600	6.0	600	4	2	1x14thd	1⅜	1⅝	1
6EC800	8.0	600	4½	2	1x14thd	1⅜	1⅝	1
6EC1000	10.0	600	4	2½	1x14thd	1⅜	1⅝	1
10EC100	1.0	1000	2¾	1½	¾x16thd	1	1¼	⅝
10EC200	2.0	1000	4½	1½	¾x16thd	1	1¼	⅝
10EC400	4.0	1000	4	2	1x14thd	1⅜	1⅝	1
10EC600	6.0	1000	4	2½	1x14thd	1⅜	1⅝	1
10EC800	8.0	1000	4½	2½	1x14thd	1⅜	1⅝	1
15EC50	.5	1500	2¾	1½	¾x16thd	1	1⅛	⅝
15EC100	1.0	1500	4½	1½	¾x16thd	1	1¼	⅝
15EC200	2.0	1500	4	2	1x14thd	1⅜	1⅝	1
15EC400	4.0	1500	4½	2½	1x14thd	1⅜	1⅝	1

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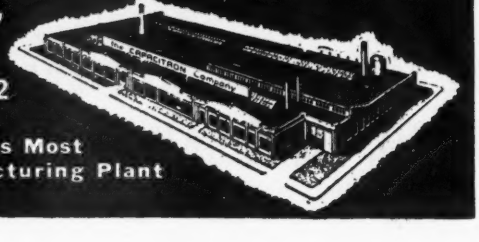

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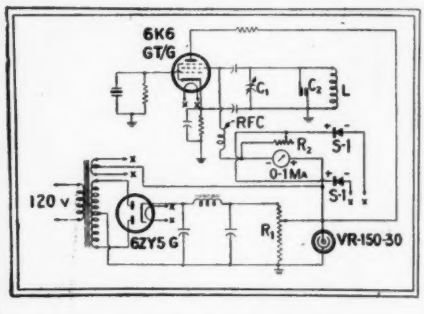
applications. The measurements provided are in agreement with test-blocks and stereo comparators and readings are reproducible within 0.002 mm, a degree of accuracy somewhat beyond that attained by operators using the optical equipment.

The essential element of the unit is a small lever, about 2 inches long, swinging on a bearing about one-third the distance below the upper end. At the upper end of the lever, a rounded surface presses lightly against one edge of the film as it passes through the gage. If the



Circuit of electronic gage for measuring width of a continuous strip such as movie film

film becomes wider, the upper end of the lever is pushed outward, and since this is above the fulcrum, the lower end of the lever swings inward. As the lever swings, a metal disk at the lower end moves nearer to, or farther from, a similar disk which is fixed and immovable. These two metal plates never actually touch one another, but as the distance between them varies with variation of film width, they actually constitute a variable capacitor.

With change of film width, there is a change in capacitance of the variable capacitor and this change is amplified electronically, giving a direct reading or recording of film width in millimeters. Thus, with but one moving part in the actual measuring mechanism, variations of film width are measured in a fraction of a second, and the most minute changes are amplified to a degree allowing clear and easy reading, without injury to film from pressure.

Mechanical Arrangement

In the unit, the film passes from the feed roll, under a guide-roller, through the measuring head, under a second guide-roller and to a take-

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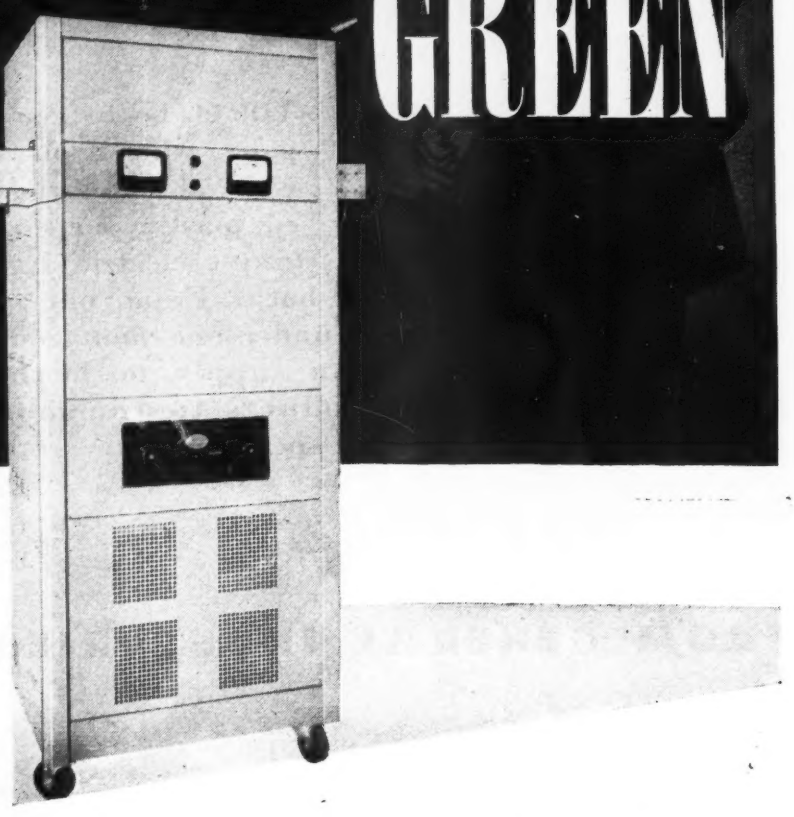

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RECTIFIER G ENGINEERS

up roll which is driven by a motor. Guide rollers, measuring head, and spindles for the film rolls are all constructed so that 8-mm, 16-mm, or 35-mm films can be measured interchangeably.

The measuring head consists of a fixed lateral film guide which is adjustable for any standard width of film, a ballbearing film-supporting roller and a movable lateral film guide which is attached to the swinging lever, with a movable capacitor plate attached to the lower end.

As the film passes through the measuring head, it is curved over a ballbearing film-supporting roller. The path described by the film in passing over this roller forces it into a partially cylindrical contour at the point of measurement, thereby inducing lateral rigidity and assuring that the true width of the film will be measured. This simple method of film-guidance is one of the prime factors insuring accuracy and reproducibility of readings with the instrument.

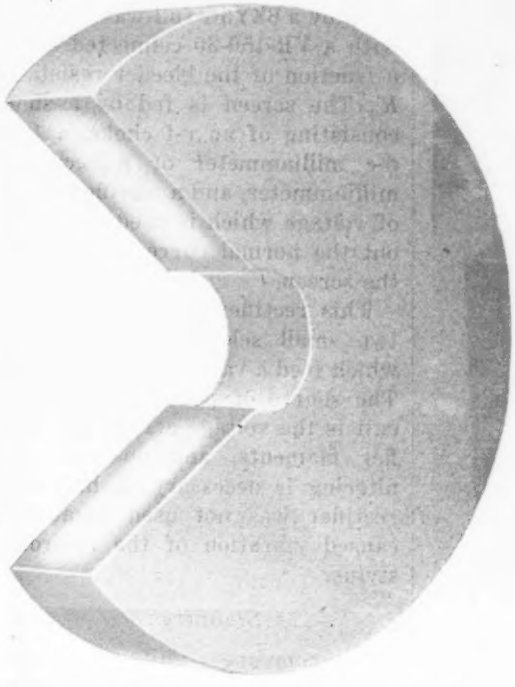
Use of Oscillator

Small variations of capacitance can be measured conveniently by their effect upon the frequency of an oscillator circuit or by their effect upon the amplitude of current in a parallel resonant circuit and this principle is used in the electronic width-gage. Essentially it is a fixed vacuum-tube oscillator loaded by a variable tuned circuit, the impedance of which varies with the capacitance fluctuation of the mechanical capacitor C_2. As a result, the direct current flowing through the vacuum tube varies, and these variations are directly proportional to variations in width of the film or other object being measured.

Capacitor C_1 is a fine control to compensate for minor fluctuations in frequency. If reproducible results are desired, it is extremely important that the resonance at which the circuit operates be confined to one point on the resonance curve. Assuming that the overall capacitance is changed by a very small amount to some value less than that required, the change of current for a given change of capacitance will be less because of the nonlinearity of the resonance curve.

The source of oscillation is a

two-day curing job.. cut to 7½ minutes



Cross section of grinding wheel . . . formerly oven baked . . . heat soaks in slowly from surface.

Same section . . . now cured by radio-frequency heating . . . heat builds up speedily, evenly throughout.

The old, slow oven cure took 48 hours—just to heat the resin bond of a grinding wheel 8½" in diameter by 1¼" thick.

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Single standard units are available in output capacities ranging up to 200 kw. The range of frequencies is wide enough for almost every dielectric and induction heating need. For more information, write for Descriptive Data 85-800. Or, for suggestions on a specific application, ask a Westinghouse engineer to call. Westinghouse Electric & Manufacturing Co., P.O. Box 868, Pittsburgh 30, Pa. J-08097

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quartz crystal connected to the grid of a 6K6GT/G vacuum tube. The parallel resonant circuit is connected to the screen grid, a feature of design leading to increased stability of operation. The plate and screen grid are operated at half their rated voltages. Power is supplied by a 6ZY5G full-wave rectifier with a VR-150-30 connected across a fraction of the bleeder resistance R_1. The screen is fed by a shunt consisting of an r-f choke, a 1-ma d-c milliammeter or a recording milliammeter, and a rectified source of voltage which is used to balance out the normal current flowing in the screen.

This rectifier circuit consists of two small selenium rectifiers, S_1, which feed a variable resistive load. The source of power for this circuit is the voltage across the rectifier filaments, and no additional filtering is necessary. A half-wave rectifier was not used because it caused vibration of the recording stylus.

Stability

The component units of the electronic circuit were selected to minimize the generation of heat, since the impedance of a tuned circuit and of the tube elements are functions of the surrounding temperature. Accordingly, the screen-grid current will fluctuate if the necessary precautions are not observed to prevent fluctuations of temperature. With the present circuit, after approximately five minutes for heating, no drift in screen-grid current was noticed during continuous operation for 48 hours. The stability of the circuit is excellent.

Operation of the circuit is illustrated by the graph, which shows the relation between screen-grid current and capacitance of the resonant circuit. In a crystal oscillator circuit, the resonance curve is not symmetrical, one side of the curve having a slope much greater than the other. This effect is caused by the influence of the tuned circuit upon the crystal impedance. When film is held between the fingers, as in threading the width-gage, the capacitance is varied so the circuit is no longer in resonance, as indicated by a or some other point on the curve. The direct current I corresponding to a point a is balanced until the meter reading cor-

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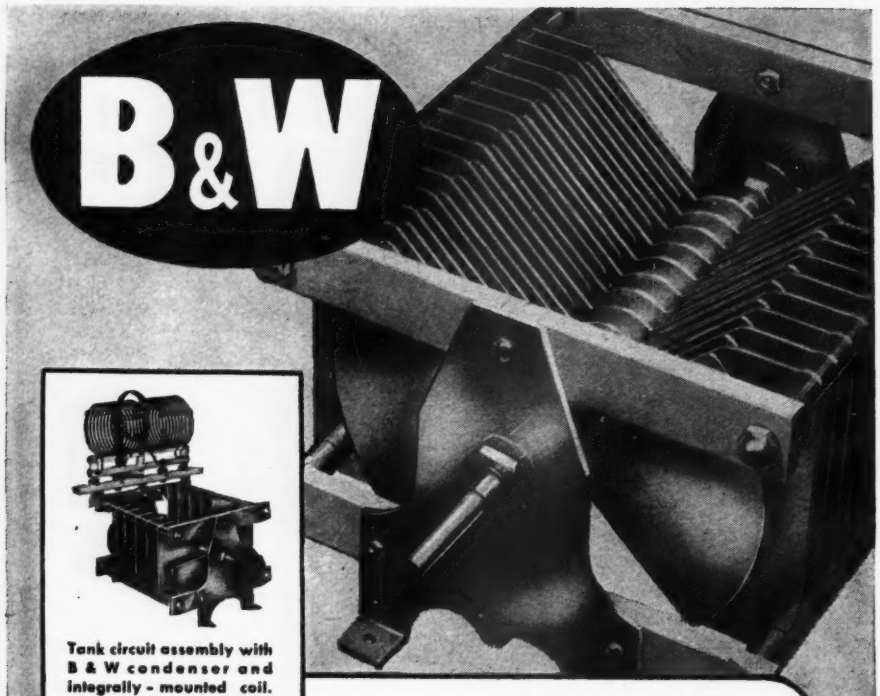

Tank circuit assembly with B & W condenser and integrally - mounted coil.

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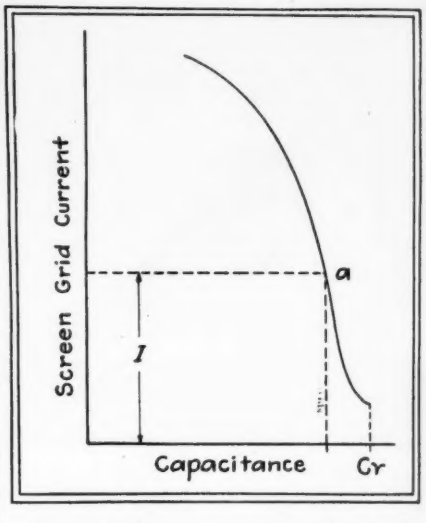
responds to the desired reading on the scale. As the width of the film becomes greater or less than the width corresponding to a zero setting of the width-gage, the meter indicates a flow of current greater or less than the value represented by the point *a* on the curve. Once this point for correct operation has been determined, calibration of the instrument becomes simple.

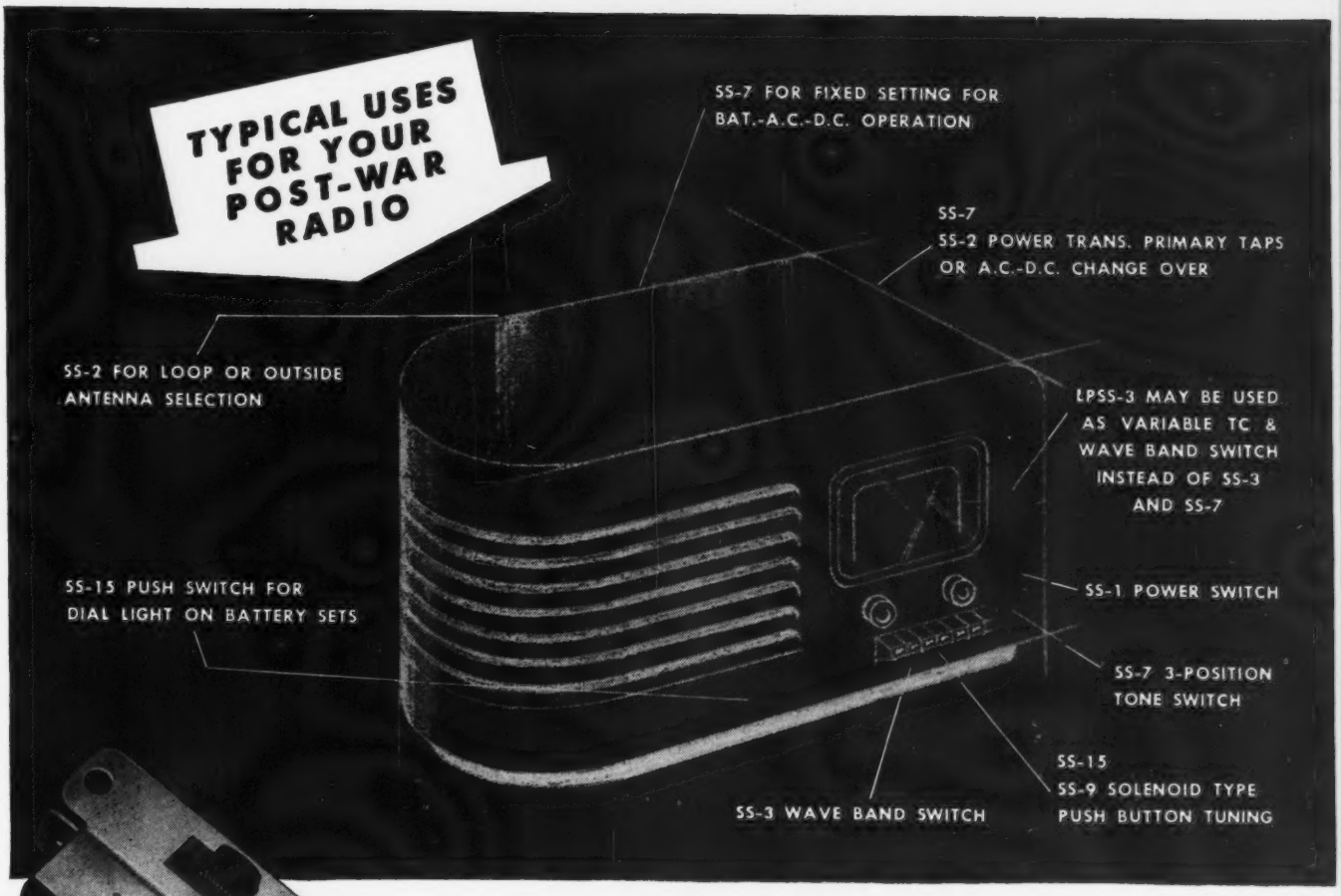
The difference in current can be materially amplified by increasing the Q value of the resonant circuit. The sensitivity to small changes of capacitance can be increased also by increasing the frequency of the generator.



Graph of change in screen-grid current plotted against change in capacitance of a resonant circuit in an oscillator

For linear differences of current with changes of capacitance, the circuit should be operated on the part of the resonance curve where the change of slope is zero. With only small changes of capacitance, such a portion of the curve does exist for practical purposes. In this instrument, described by S. C. Coroniti and H. Scott Baldwin in the *Journal of the Society Motion Picture Engineers* for November, 1943, this portion of the curve corresponds to a linear response for changes of capacitance effected by variations of film width not exceeding 0.25 mm.

By replacing the d-c meter by a recording milliammeter, continuous automatic recording of variations in width can be achieved. The speed of the recording chart and of the film can be adjusted to suit the convenience of the operator.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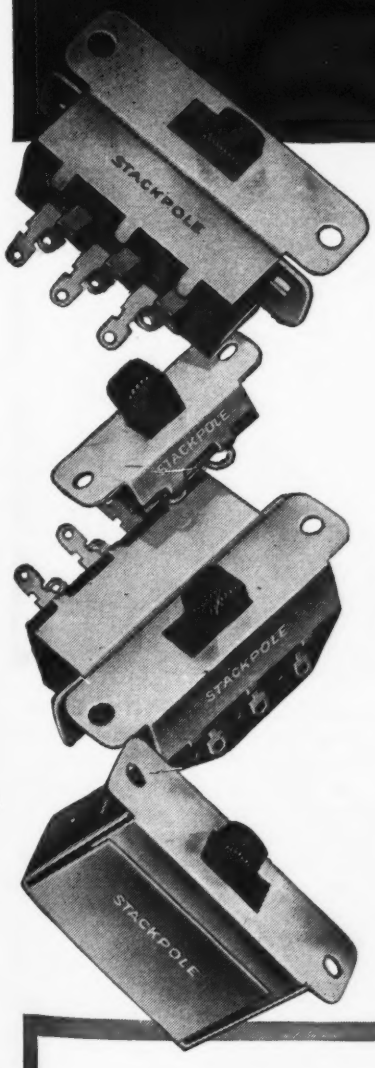
SS-15 PUSH SWITCH FOR DIAL LIGHT ON BATTERY SETS
SS-1 POWER SWITCH
SS-7 3-POSITION TONE SWITCH
SS-15
SS-9 SOLENOID TYPE PUSH BUTTON TUNING
SS-3 WAVE BAND SWITCH



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TUBES AT WORK

Operational Flight Trainer Uses 200 Tubes 214
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Single-Side-Band Transmission 230
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Music Sets Speed for Teletype Students 258
Deficiencies of Group Hearing Aids 262

An intermediate-frequency transmitter is tuned by the radioman in the training mock-up of the forward section of a PBM-3 Mariner. All equipment operates normally, as does intercom system

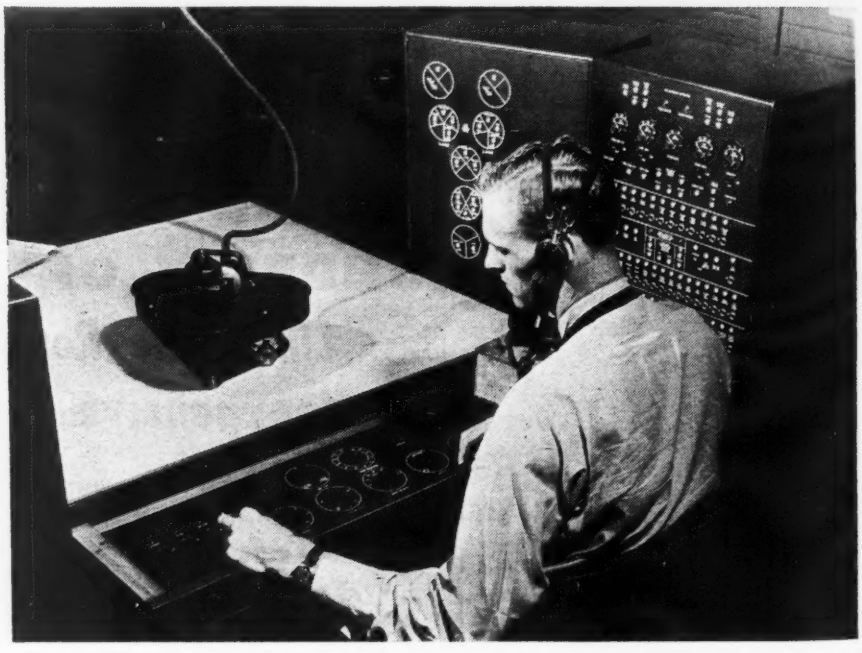
Operational Flight Trainer Uses 200 Tubes

BUILT TO RESEMBLE the interior of an actual plane, a stationary operational trainer used by the Navy uses over 200 electronic tubes and about sixty electric motors to simulate flying conditions on a PBM-3 Mariner. In addition to the normal electronic equipment used for navigation and communication, electronic units are used in computing circuits that enable an instructor to tell whether the pilot, co-pilot, radioman, navigator and flight engineer are doing what they should under various conditions in flight.

Features of the new crew-trainer are shown in the photographs. These include a mock-up of the forward portion of the plane which contains all of the regular operating controls. Steps lead through narrow passageways to the upper deck, where are located all the flight engineers' panels with their instruments, switches and knobs, primarily for engine control. On the port side is the chart table and navigator's seat and on the starboard are the radio units with a desk and chair for the radioman. In the cockpit are positions for pilot and co-pilot, with duplicate flying controls and instruments, and a bank of indicators and switches in the center.

Electronic circuits also operate loudspeakers to simulate engine noise and vibration. Starting and stopping the engines, taking off, flight, and landing operations are tied into the intricate system, and provide the proper instrument indications.

In an adjacent room, an instructor's desk contains instruments that duplicate those in the plane, at the pilot's, engineer's and radioman's positions. By watching these instruments, the instructor can see just what is going on in the plane at all times. He can also listen in on the crew's intercom conversations and hears all radio messages passing between the plane and a simulated control tower. He follows the actions taken by the crew, gives instructions when necessary, monitors the actual course that would be flown as a result of the actions of the crew, and is also able to adjust conditions so as to find out how the crew responds to emergencies or to changed conditions of flight.

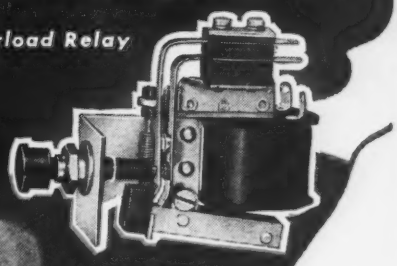


Flight problems for the crew in the electronically-equipped trainer are set up by the instructor. Values of wind velocity, direction, rough air, wing ice, etc., are determined by the knobs. Monitoring of the crew's actions is done with the aid of the indicator panel at the right and the flight recorder (called the "crab") on the desk that automatically follows the course flown

The instructor causes changed conditions such as velocity and direction of wind, icing of the wings, rough air, changes in weight and center of gravity, and he can disable either or both of the engines.

At the instance of Captain Luis de Florez, USNR, head of the Bu-

relays FOR OVERLOAD PROTECTION IN ELECTRIC SHOCK TREATMENTS



Series L Overload Relay

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Offner Electric Shock Therapy apparatus has been widely prescribed for treatment of psychiatric patients for more than five years. From the very first experimental model to present-day production units, Guardian Overload Relays have been used exclusively to protect the patient from dangerous current surges.

Offner Electric
Shock Therapy Apparatus

Relays BY GUARDIAN

In certain types of mental disorders it is possible to shock patients back to normal by passing an electric current through brain tissues. Naturally the patient must be protected against the possibility of excessive current surges. Such protection must be positive—dependable. In providing this protection, Guardian Series L Overload Relays have established a perfect record for safe, dependable performance in hundreds of thousands of known treatments.

The Series L Overload Relay provides accurate protection against surges and overloads. Standard coils attract on 150, 250, 500, or 750 milliamperes; coils for operation on other current values are available on specification.

The large, oversize contacts used on this relay can take severe overloads without damage. They are rated for 1500 watts on 110 volt non-inductive A.C. and in A.C. primary circuits of any inductive power supply delivering up to and including 1 kilowatt. Contacts lock open and cannot be reset until overload is removed. For further information, write for Series L bulletin.

Consult Guardian whenever a tube is used—however—Relays by Guardian are NOT limited to tube applications, but may be used wherever automatic control is desired for making, breaking, or changing the characteristics of electrical circuits.

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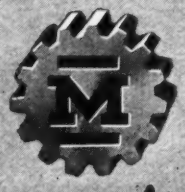
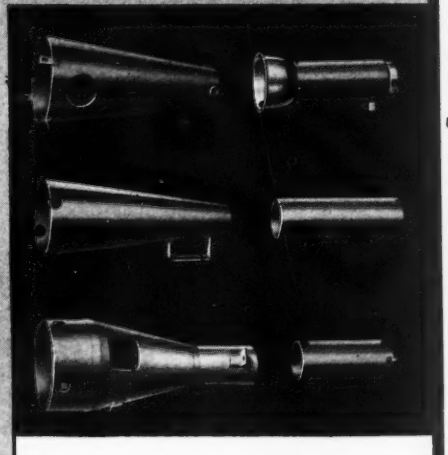

Application



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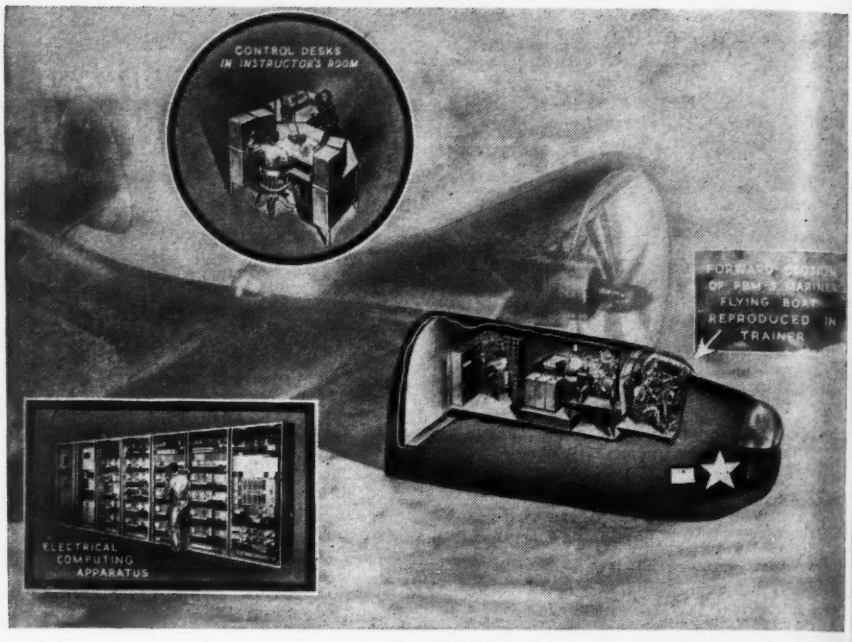


Important sections of the operational flight crew trainer used for instructing Navy airmen under operating conditions without leaving the ground. More than 200 electronic tubes and 60 electric motors are in the equipment

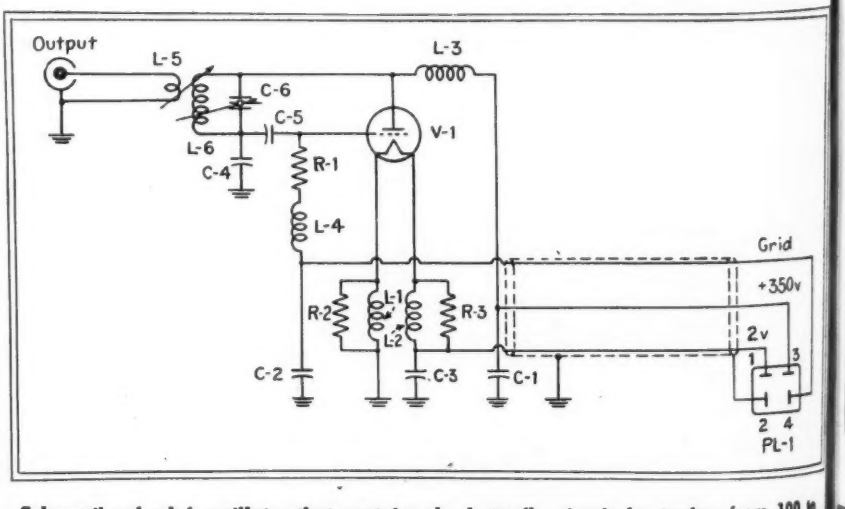
reau of Aeronautics' Special Devices Division, the first crew trainer of this type, designed and built by Bell Telephone Laboratories in 1943, was installed by the Navy at its training center at Banana River, Florida, where it is now in use daily. Subsequent trainers were built by Western Electric Company.

One of the trainers is now in use at Patuxent River, Maryland, where it is used by Naval Air Transport Service in training oceanic flight crews. This unit was shown to the press in January.

Butterfly Circuit in V-H-F Oscillator

A NEW WIDE RANGE oscillator that covers frequencies from 100 to 500 megacycles is shown schematically in the illustration. By use of the new butterfly circuit as the frequency-determining element, all sliding contacts have been eliminated.

For a 120-deg rotation of the capacitor rotor, the effective capacitance of this circuit varies by a factor of 10.6 from 94 $\mu\mu$f to 8.8 $\mu\mu$f, and the effective inductance by a factor of 2.9 from 30 cm to 10.3 cm, giving a frequency range of 95 Mc to 525 Mc. The capacitance variation of the tuning circuit alone is considerably better than these



Schematic of v-h-f oscillator that contains the butterfly circuit for tuning from 100 to 500 Mc without sliding contacts

OWI Photo by Palmer in an Allegheny Ludlum plant

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THOSE slabs and billets of special high-alloy steels, awaiting further processing in Allegheny Ludlum plants, are raw materials for the world's finest mechanical equipment. They're also the main reason *why* it's the finest. Special steels give the extra performance—the superior electrical properties, or strength and toughness, or resistance to heat, wear and corrosion, as the case may be—that gives one product the edge over another.

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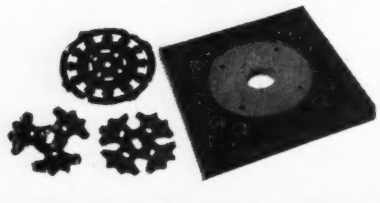
A fungus likes its "supper" warm and wet!

—but it won't get fat on INSUROK T-640!

Here is a modern precision plastic that's tailor-made for the humid, spore-laden atmosphere of the tropics. Under conditions where hungry, fast-growing fungi and mildew eat their way into equipment, destroying it in a matter of hours—INSUROK T-640 is proving its ability to out-last and out-perform ordinary materials . . . *with or without protective finishes.*

The reason is simply that, so far as we know, there is no laminated phenolic plastic which has the *low moisture absorption* of Laminated INSUROK, Grade T-640. In addition, it has uniform dielectric and mechanical characteristics, and can be fabricated. These and other features make INSUROK T-640 ideal for use with radar, communications receivers and transmitters, and a variety of other war or peacetime products. Write for complete information about INSUROK T-640. Or ask Richardson Plasticians to suggest a grade or type Laminated or Molded INSUROK best suited to your needs.



Punched and fabricated parts made of Laminated INSUROK T-640, typical of those used extensively in radio and electronics industries where low moisture absorption is essential.

INSUROK *Precision Plastics*

The RICHARDSON COMPANY

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CLEVELAND OFFICE: 324-7 PLYMOUTH BLDG., CLEVELAND 15, OHIO

figures indicate since the grid-to-plate capacitance of the oscillator tube and a trimmer capacitor are added to the minimum capacitance.

Grid and plate of the oscillator tube are connected directly across the tuned circuit as shown in the diagram. The filament of the tube is fed by chokes, allowing it to assume a potential determined by the electrode capacitance of the tube and by the capacitance of the tuned circuit to ground. This latter capacitance is adjusted to optimum value by a small grounding capacitor. To compensate for variations in tube electrode capacitance, a trimmer capacitor is provided.

The main dial is calibrated directly in megacycles. The vernier dial carries 100 uniform divisions and covers the tuning range in approximately 10 revolutions. An auxiliary scale on the main dial indicates revolutions of the vernier.

Power Supply Indicator

A type 316-A vacuum tube is used in the oscillator circuit. Connections to a separate power supply are made through a 4-conductor shielded cable permanently attached to the oscillator.

The plate voltage supplied is 350

• • •

F-M ANTENNA ON HIGH

A new two-bay General Electric circular antenna was recently installed by Columbia Broadcasting System engineers atop the 700-ft building at 580 Fifth Avenue, New York City for use by station WABC-FM. Provision has been made for adding two more bays to this 14-ton structure, the height of which is 100 ft above the roof. When the antenna is put into use, CBS will have the first f-m station in New York City to cover its assigned area

BH NON-FRAYING FIBERGLAS SLEEVING

ENDS "WIRE THREADING" WORRIES

INSERTING bare wire in rough sleeving that frays out on the ends is time- and patience-consuming. The job is much simpler and less irksome when you use BH *Extra Flexible* Fiberglas Sleeving, the non-fraying, smooth bore insulation that takes fine-stranded wires without a hitch.

Special-processed BH Sleeving is *permanently* flexible and non-fraying. It won't harden and crack with age, and it won't burn. In addition, it has all the other desirable electrical and physical features of inorganic Fiberglas.

If you're looking for an easy-working, long-lasting insulation, why not try BH *Extra Flexible* Fiberglas Sleeving? It's available in all standard colors and sizes from No. 20 to 5/8", inclusive. Write for samples today!

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Speed Up Power Tool Assembly

Your workers can pick up Palnuts automatically with a power driver from a "supply tray", then run them onto work without handling or starting with fingers.

This is possible only with Palnuts because of their unique construction. Rounded top permits easy pick-up with simple Palnut socket attachment. Eliminates fumbling and frequent dropping of nuts. Assembles speedily in any position, whether driver is vertical or horizontal.

OTHER SAVINGS! One Palnut takes the place of a nut and lockwasher. You tighten and lock with *one* piece, saving parts—time—weight—cost, while speeding assembly.

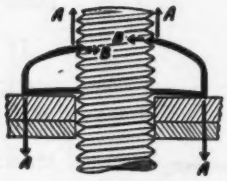
Send description of your assembly for specific recommendations and samples. Write for Palnut Manual No. 2, which gives detailed information.

THE PALNUT COMPANY

77 Cordier St. Irvington 11, N. J.

● This Palnut Socket for Yankee and power drivers has a spring finger inside which holds Palnuts securely in socket while starting them on thread and tightening to locked position.

DOUBLE LOCKING ACTION



When the Palnut is tightened, its arched, slotted, spring steel jaws grip the bolt like a chuck (B-B), while spring tension is exerted upward on the bolt thread and downward on the part (A-A), securely locking both.

Self-Locking PALNUTS

volts, which is the highest voltage that can be used unless precautions are taken to prevent destruction of the oscillator tube if oscillations are stopped by overcoupling to the load. In addition to filament and plate supply circuits, the power supply contains an electron-ray tube connected to indicate the grid current of the oscillator. The eye of the indicator tube is closed in operation and opens when grid current is interrupted.

Coupling to the load is inductive and is varied by turning the shield of the output jack between two positions marked maximum and minimum, and further variation of the coupling is obtained by moving the output jack in and out through the metal housing.

The maximum power output obtainable from the oscillator is approximately 1 watt at 500 Mc and is greater at lower frequencies.

Made by General Radio Company, the unit replaces the type 757-A v-h-f oscillator announced in 141. Both use the same tube but the new unit is half the size and weight.

• • •

Enemy Radiosondes Compared to Ours

CAPTURED ENEMY RADIOSONDES give fewer readings than ours and therefore are less accurate. They are well built and well designed, and are smaller in size and lighter in weight than American instruments. Their mercury thermometers and manometers are not suited for mass production since certain component parts can be made only by hand, and at least two precalibrations are necessary. The foreign instruments use vibrators and transformers to obtain desired voltages and alternating currents.

The Germans have two types of radiosondes in general use. One type employs wet and dry bulb mercury in glass thermometers for measuring temperature and relative humidity, and a mercury-filled glass manometer for determination of pressure. The glass tubes have metal coils on the outside distributed through the operating length of the mercury columns within the glass tubes. Two transmitters are used, and two radio frequencies and two antennas are required. Constant tracking of the signals at

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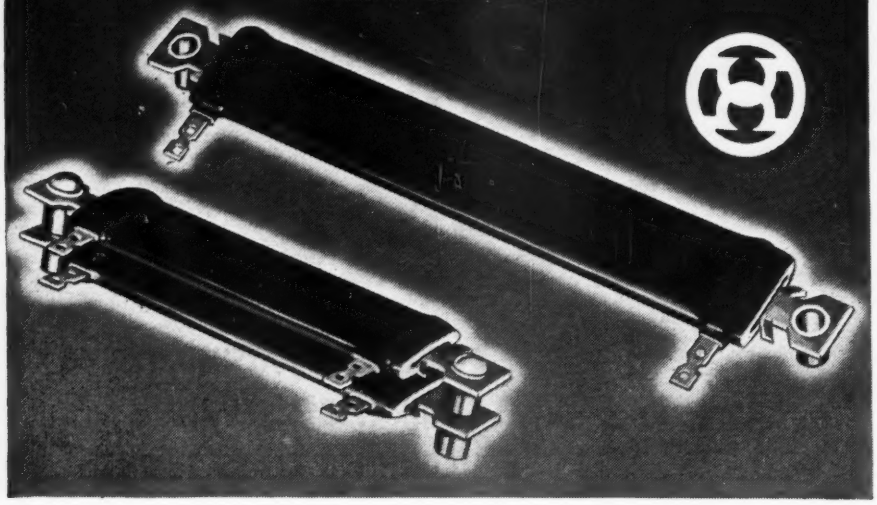

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They still lead the field as the most efficient:—their compactness, their toughness, and their remarkable performance offer you more than just higher wattage ratings for unit space required.

—And in our other types of resistors and rheostats we also offer you important exclusive advantages.

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ESTABLISHED 1886
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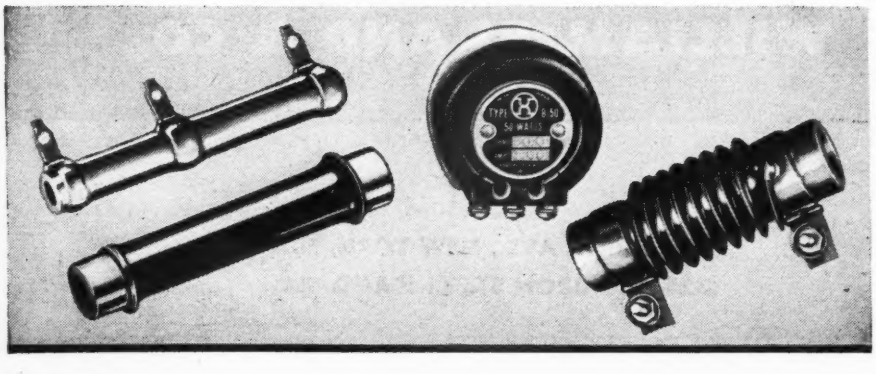


the ground station is apparently required to operate this set.

Chronometric radiosondes that employ bimetallic elements to measure temperature, and hair hygrometers to measure humidity are also used by the Germans. Temperature contacts are made twice a minute, humidity contacts once a minute.

In Japanese radiosondes, pressure is determined in much the same way as in the chronometric instrument of the Germans; however, there are only seven contacts. These also must operate on two radio frequencies.

Our radiosonde operates with one transmitter whose carrier is audio modulated. Variation in audio modulation can be translated into meteorological data. The signal is received and graphically recorded on a chart. The number of contacts can be counted and the pressure read. Then the elevation is determined. Some American radiosondes have 80 contacts; others 95.

• • •

Sound Equipment Spots German Guns

WITH THE BRITISH Fifth Army, electronic sound equipment in listening posts is used for plotting the location of enemy gun positions.

When the report of an enemy gun reaches a listening post in the forward area, a man on duty presses a button which starts the recording machine of a sound ranging unit at headquarters. As the sound wave reaches each of several microphones or resonator, spaced out along the hill, it is converted into an electrical impulse and passed along a telephone cable to the recording machine. At the recording machine, the electrical impulse causes a wire to vibrate. There is a wire for each microphone, and an image of each wire is thrown onto a moving strip of sensitised paper. When one wire vibrates, the vibration is recorded as a sharp zig-zag which breaks an otherwise straight line. The distance between zig-zags on adjacent microphone recordings represents a time difference.

There is an infinite number of places, at increasing distances away from the microphones, which will give the same time difference for a sound wave reaching the two

14 MICRO SWITCHES

Control 12 Accurate Operations of this Stokes Molding Press Every 33 Seconds

Timing, limiting and safety operations of this Stokes Automatic molding press, which can perform a complete cycle in as little as 33 seconds; are accurately controlled by 14 Micro Switches:

The F. J. Stokes Machine Company of Philadelphia, Pa., turned to Micro Switch as the control components of this accurate molding machine because their small size, precise operating characteristics, long life and dependability most exactly met their requirements.

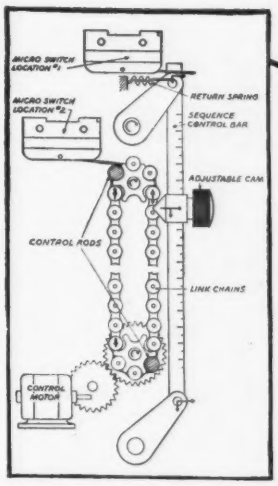
Experience of the F. J. Stokes Machine Company with Micro Switches is typical of the many uses design engineers are finding for this small, sensitive, durable, snap-action switch.

Design engineers who are planning products for the highly competitive post-war markets should be thoroughly familiar with Micro Switches and the many advantages they have to offer. We will be glad to send you as many Micro Switch Handbook-Catalogs as you may be able to use. Write for them today.

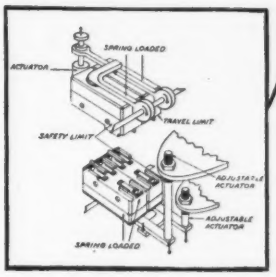
Handbook-Catalog No. 60 gives complete details on electrical characteristics, housings, and actuators.

Handbook-Catalog No. 71 gives complete information on Micro Switch for use in aircraft equipment.

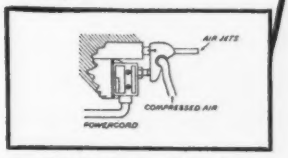
Two stars have been added to our "E" Flag as further recognition to the men and women of Micro Switch for maintaining our war production standards.



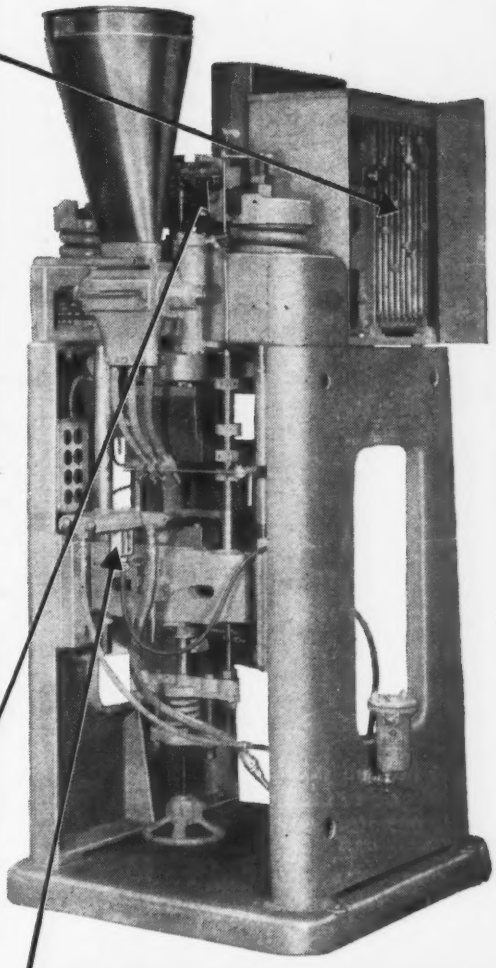
Nine Plastic Enclosed Micro Switches are used in the sequence and timer control. Eight of them are actuated by adjustable cams set along the sequence control bars. The ninth shuts off the control motor and starts the timer which determines the curing operation of the mold.



Four Plastic Enclosed Micro Switches are used—two as travel limits and two as safety limits for the press ram. The travel limits are operated by adjustable push rod actuators to stop the press ram at the correct extremes of movement. The safety limits operate only to stop the press if the others should not be set correctly.



One Die Cast Enclosed Micro Switch is used on the air and mechanical mold cleaner. It is actuated by a push rod and operates the six air jets which blow a sheet of air through the mold to blow off the molded part.



The basic Micro Switch is a thumb-size, feather-light, plastic enclosed, precision, snap-acting switch. Underwriters' listed and rated at 1200 V.A. at 125 to 460 volts a-c. Capacity on d-c depends on load characteristics. Accurate reproducibility of performance is maintained over millions of operations. Basic switches of different characteristics are combined with various actuators and metal housings to meet a wide range of requirements.

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THE ACRO ELECTRIC COMPANY

1316 Superior Avenue Cleveland 14, Ohio

microphones. If a line is drawn from a point midway between the two microphones through all the successive positions from which the sound could have originated, the result is a curve. In practice, the curve is not employed but a straight line which gives an average is used instead.

From the difference in time the sound waves takes to strike two adjacent microphones, a bearing line is obtained. Somewhere along this line lies the enemy gun. The use of a number of microphones gives a

Gunfire from enemy artillery is picked up by microphones and electronically amplified to actuate recording equipment at this gun-plotting center of the British Fifth Army

number of bearing lines, and where they intersect on the map is the position of the enemy gun. Air temperature, wind speed and direction affect the accuracy of the results, and so an RAF meteorological unit is attached to the sound-ranging troops to provide meteorological information. If enemy shellfire cuts the telephone cable, the listening post immediately switches over to radio equipment and gives the order to the recording center for the recording machine to be started. As soon as the shell has landed, the machine is switched off so as not to waste paper. In this manner, enemy gun positions which are out of sight can be pin-pointed on the map.

• • •

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Federal presents a new and rugged power tube that fills an immediate demand — a power tube that has been *specially* designed for industrial use in high-frequency heating equipment, both dielectric and induction.

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Widely spaced, unusually sturdy filament and grid elements, without internal ceramic insulation, give this tube a ruggedness that makes it the logical choice for dependability in the design of industrial heating equipment.

For industrial power tubes, and also for rectifier and transmitting tubes, see Federal first... because "Federal always *has* made better tubes."

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Filament Voltage	11.0 volts
Filament Current	27.5 amps.
Maximum Ratings for Maximum Frequency of 50 Mcs.	
DC Plate Voltage	3500. volts
DC Plate Current	1.0 amp.
Plate Dissipation	1200 watts
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Supplied with 6 "flexible copper leads, 2 on each terminal.

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ulation system has been developed by Westinghouse engineers to increase the effectiveness of the available frequency band by decreasing the width of the channels required for transmission. The new system increases the ratio of signal to noise by as much as 8 to 1, the highest of any known transmission method occupying comparable space in the frequency band.

Single-side-band signals have been generated as double-side-band signals and passed through filters to eliminate the unwanted side band. At power-line carrier frequencies it is difficult to build filters with sufficiently sharp cut-off characteristics for this purpose. Recently, circuits that permit the use of a much simpler system of single-side-band generation, requiring no filters or double modulation schemes, have been developed.

In the single-side-band system, instead of continuously transmitting a base or carrier frequency and superimposing on its amplitude the voice or signal frequencies to be transmitted, only the band of frequencies representing the carrier plus (or minus, but not both) the signal frequencies are transmitted over the power line. The carrier wave itself is not transmitted; thus, the full power available is concentrated in side-band frequencies. At the receiver end, the carrier frequency is recreated and mixed with the received side band. Demodulation is effected in the regular manner. The apparatus consists of a new unit to be added to standard amplitude-modulated equipment.

• • •

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By Perry C. Smith, Robert G. Picard and Frank E. Runge

Radio Corporation of America

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lems involved may be reached. Coupled with the above, is the problem of controlling the specimen from the exterior of a highly evacuated microscope column while at the same time not raising the pressure within the column. Design consideration must also be given to convenience of control and mechanical simplicity.

Electron microscope specimens are generally mounted on a thin film or supporting membrane, as the usual microscope slide is much too thick to be penetrated by the electron beam. Suitable films are made by casting a 2 percent solution of collodion on distilled water. As a result of low surface tension, the film material and its solvent spread out over a large area on the surface of the water. After the solvent has evaporated, the specimen is affixed to a film and supporting screen by one of several simple techniques. The film itself varies in thickness from approximately 0.0000004 inch to 0.000001 inch depending on the percent solution and solvent used. Films of these dimensions are strong enough to retain most types of specimens, are transparent to the electron beam, and show no structure of their own in the photographic image.

Use of Screen

To provide a rigid yet electron-transparent support for the rather delicate film and its included specimen, another prop is required. Generally, this is a 200-mesh screen about $\frac{1}{8}$ inch in diameter which provides the equivalent of the glass slide common to light microscopy. Thus, a typical specimen ready for examination by electron microscopy can be imagined as a three-layer assembly consisting of a 200-mesh metal screen, a thin collodion membrane and a dispersed assortment of specimen material.

Since the penetrating action of high-speed electrons is limited to distances of about 0.00004 inch, the metal portions of the 200-mesh screens are opaque to the electron beam. A screen of 200 mesh provides an optimum number of supporting points for the collodion films, and allows a sufficient and convenient window area for specimen observation and photography. The requisites of a good screen are: 25 percent or greater total window

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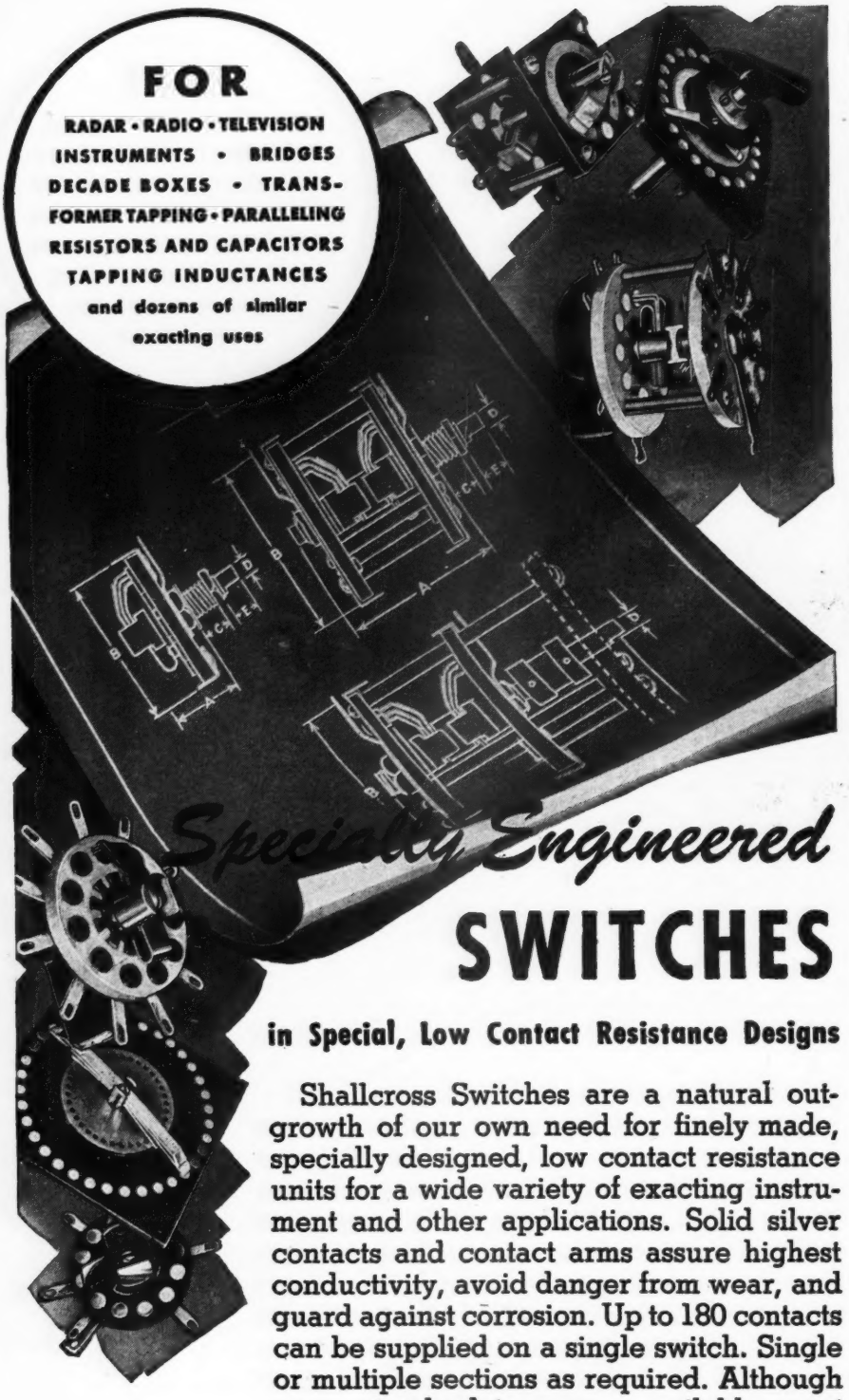

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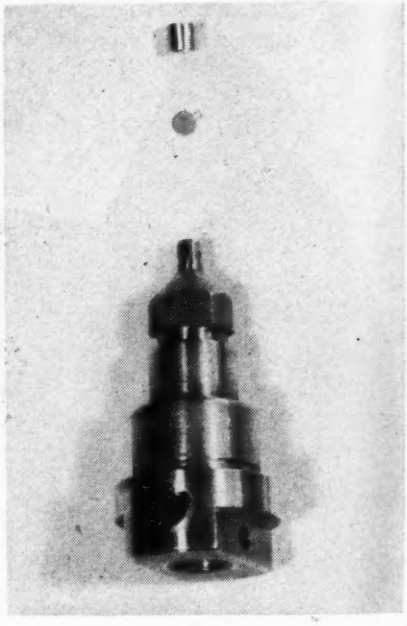
area and a clean, smooth-sided mesh made of a chemically inert material. Woven stainless steel screen which has been rolled flat until the warp and woof present practically a plane surface fulfills the requirements.

Other techniques omit the collodion film. For example, metallic oxides will cling readily to the metal screen surfaces and inner edges of the mesh. The screen is



Adjustable high-magnification specimen holder. Above it are the specimen screen and screen holder cap

coated by simply holding it in the smoke of the burning metal. Thus, it is obvious that clean smooth-mesh screens are a necessity to avoid misinterpretations of results.

Cartridge Types

Prepared specimen screens are loaded into small specially designed brass cartridges to facilitate handling and insertion of the specimen into the microscope column. Cartridges may be of various designs to accommodate varying problems and techniques. An adjustable length cartridge provides control of specimen-objective lens spacing, thereby adding to the magnification ranges obtainable through varying the focal lengths of the objective and projector lenses only. Through means external to the microscope, another design of cartridge can be made to tilt the specimen at an angle, first to one side of the electron optical axis and then to the opposite side an equal amount. The

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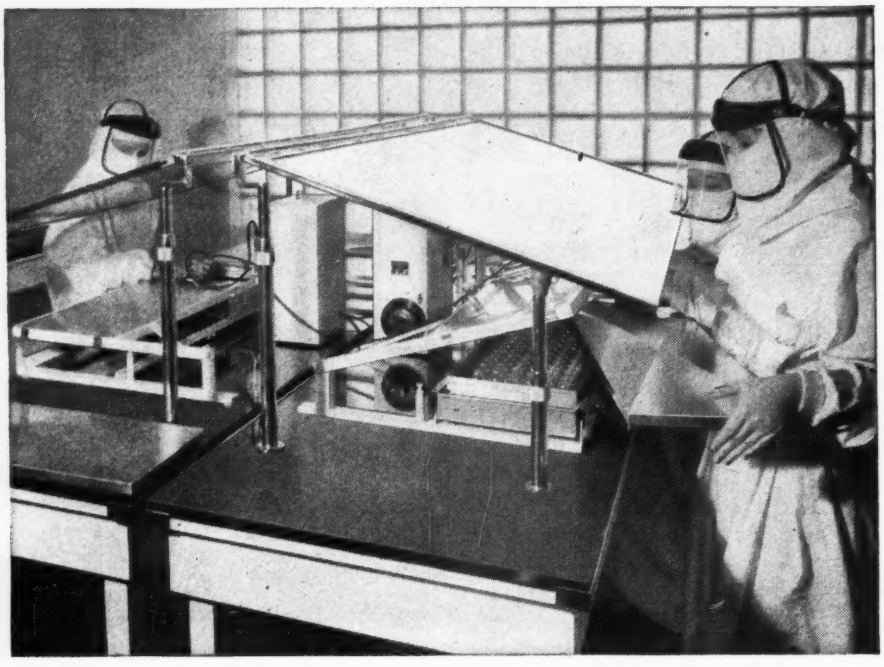

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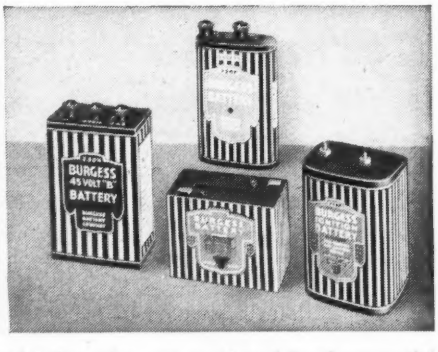

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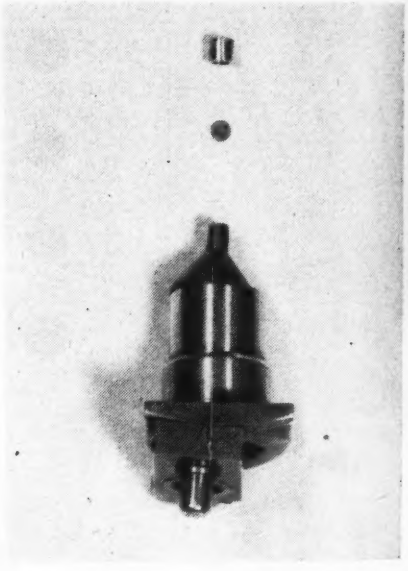
pair of negatives produced by this process, when viewed with a stereoscopic lens system, produces three-dimensional or stereoscopic images.

A $\frac{1}{8}$-inch diameter, 200-mesh screen contains about 500 holes, each hole being about 0.0025 in. square. Only 25 to 30 holes, roughly 5 percent, are scanned for specimen material and are more than sufficient for practically all studies. To scan an area 5 holes on a side, requires a specimen stage movement in one direction of 0.025 in. and another movement, at 90 deg to the first, of an equal amount.

Since direct electronic magnification may range from 100 to 20,000 times, the image of the boundary of a specimen screen hole may be $\frac{1}{4}$-in. square or it may expand to



Stereo specimen holder tilted to one side for making one of a pair of stereo negatives

slightly over four feet on a side. Considering that micrograph negatives can be photographically enlarged up to more than 10 times before the grain of the emulsion becomes a limiting factor in the quality of the details of the enlargement, it is interesting to speculate on the possible theoretical area of an enlargement of a screen window —it could embrace more than 1600 square feet!

Stage Movement

Since movement of the specimen within the microscope column is accomplished by means of a rotatable control which is coupled to the specimen stage through mechanical linkages and gear reducers, and

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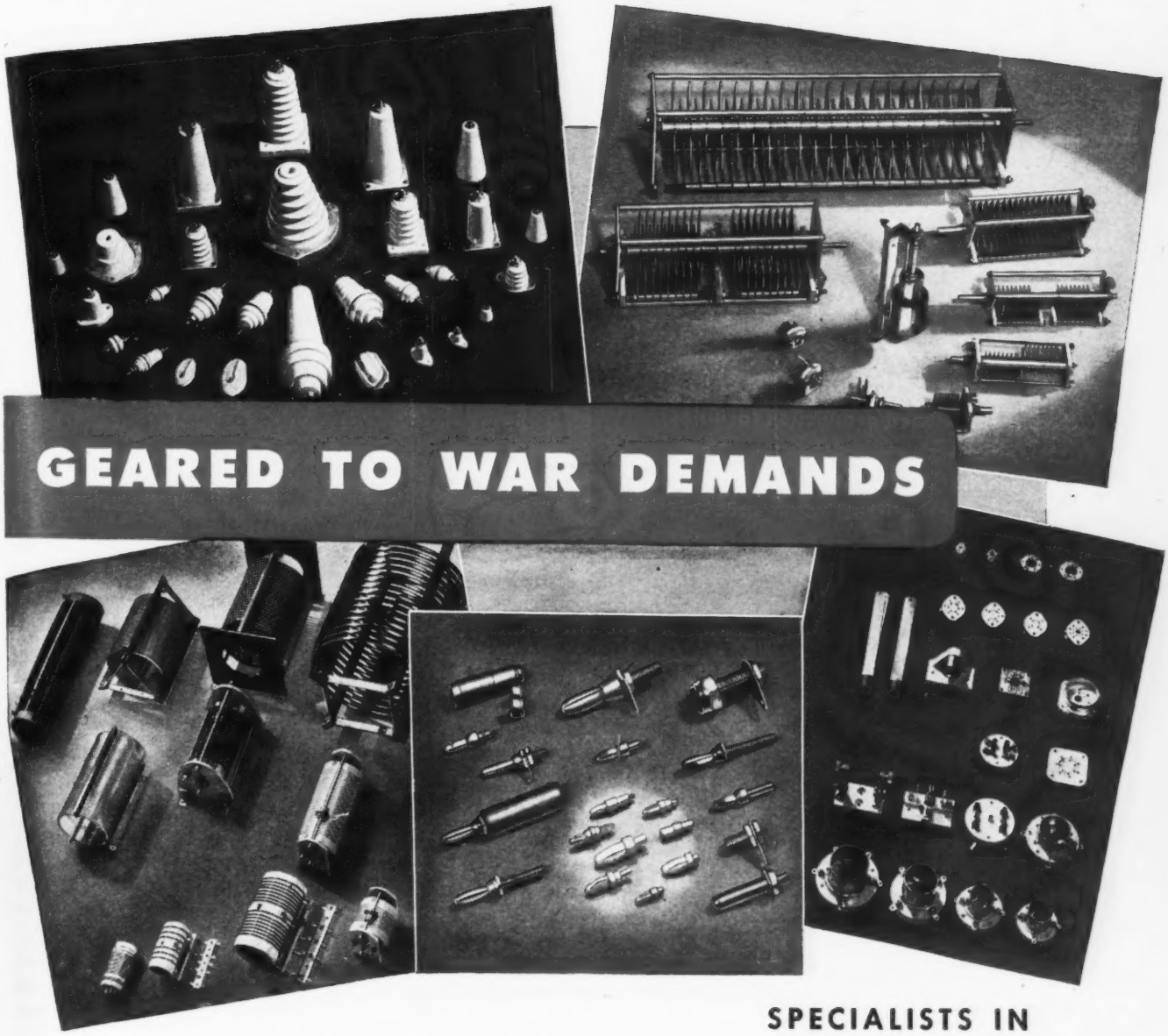
since a wide range of direct magnification is involved, an optimum of linear movement of specimen with respect to rotation of the manual controls must be chosen. For a direct magnification range up to 20,000 times, a 30-deg rotation of a able with the RCA universal microscope, a stage displacement of 0.001 inch for each rotation of a control knob was found to be most satisfactory. Thus, considering a fluorescent viewing field 3 in. square at 20,000 times, a 30-deg rotation of a control knob will produce an entirely new field provided the frame of the viewing screen is in correspondence with the frame of the window of the specimen screen. Lack of correspondence is caused by the spiral path imparted to the electron beam when acted upon by electro-magnetic fields. The stronger the magnetic field, the finer is the pitch of the spiral. Although the specimen stage movement and specimen may be in exact correspondence with the viewing

Tongs are used to insert the stereo holder into the object chamber and stage

screen mechanically, the image of the specimen may be circularly out of correspondence by anything less than one revolution for any given set of electron optical conditions.

Scanning Fields

As magnification is decreased, proportionately greater rotary movement of the control knobs is required to exchange one field for another. In any event, twenty-five rotations of each control knob must be made to move the specimen stage its permitted freedom of 0.025



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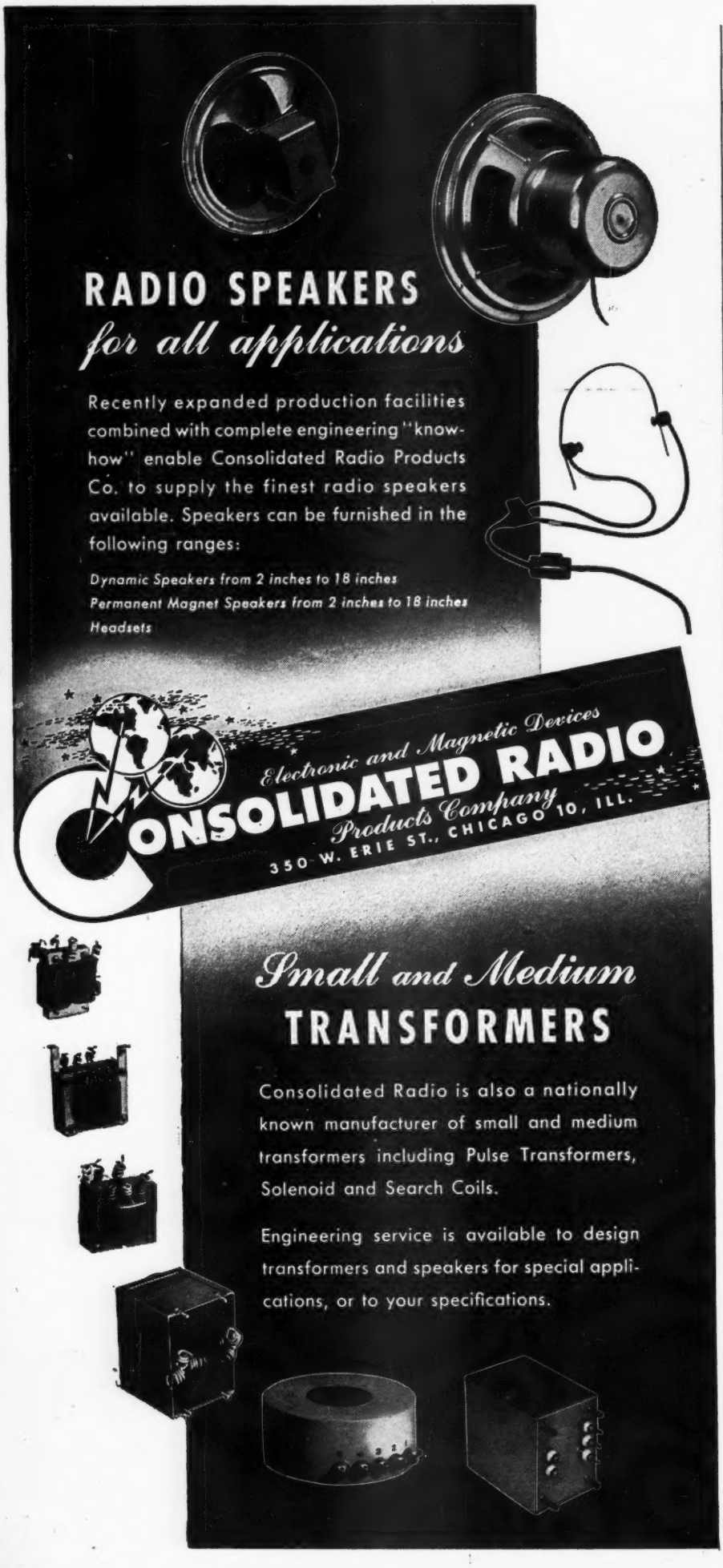
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inches in either direction. To facilitate rapid scanning of the twenty-five selected holes of the viewing screen, each control knob is provided with a small stem handle near its periphery. These handles permit the control knobs to be "spun" and image fields rapidly checked for items of major interest; yet the controls are sufficiently accurate to permit positioning the image to within $\frac{1}{4}$ inch at maximum magnification, a displacement corresponding to a specimen movement of less than *3 millionths of an inch.*

The RCA console microscope with a direct maximum magnification of 5000 times is designed with specimen stage control knobs which move the specimen at a faster rate. Each revolution of a knob moves the specimen 0.010 inch. Thus one field may be exchanged for another on the 3-in. diameter viewing window by rotating a control knob approximately 25 deg. Since the viewing field is circular, image rotation and frame correspondence do not affect the total movement required to exchange fields although the direction in which the transfer takes place is still a random route for different electron optical conditions. Mechanical considerations in the RCA console microscope have allowed greater stage movement to be obtained. About 10 percent of the screen windows—100 openings—can be examined for wanted materials.

Vibration

An important factor in specimen stage design is the filtering of mechanical vibrations. It is generally sufficient to shock mount the microscope column from the cabinet to overcome average building vibration. Under extreme conditions, the whole microscope cabinet is also shock mounted. Vibrating parts within the cabinet are individually shock mounted. Since the effects of mechanical disturbances become more deleterious as magnification is increased, filtering must be adequately designed to protect the specimen stage at the highest magnification of the instrument. Specimen stages are equipped with tiny clamping springs which prevent the specimen cartridges from vibrating independently of

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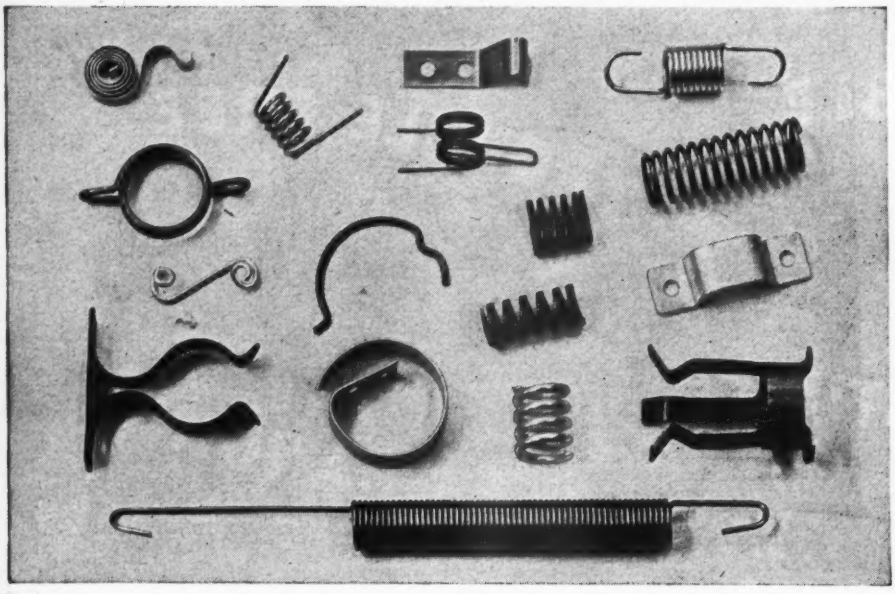

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the stage. A spurious vibration of as little as one-millionth of an inch at the specimen stage can completely destroy the identity of the smaller particles encountered in electron microscopy.

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AT UNITED AIR LINES' communications school at Chicago, music from a record player is a new wrinkle in training communications fledglings to master the rhythm, accuracy and speed necessary to operate teletype machines. Daily practice sessions are accompanied by amplified recorded music, and instructors of the company's educational department say the plan has increased average speed on time tests as much as 10 to 15 words a minute after three weeks of training.

An average of 20 girls are enrolled in each seven-weeks' United Air Lines communications class, studying company policy, meteorology, weather reporting, radio and leased wire procedures. As explained by D. I. Peterson, supervisor of the training program, anyone familiar with typing can operate a teletype machine with practice, but the teletype requires a different touch than a typewriter and is geared for a set speed—usually 65 words a minute. It must be operated in rhythm to attain speed

An instructor checks the speed of a teletype student who listens to music from a record player to establish rhythm and speed

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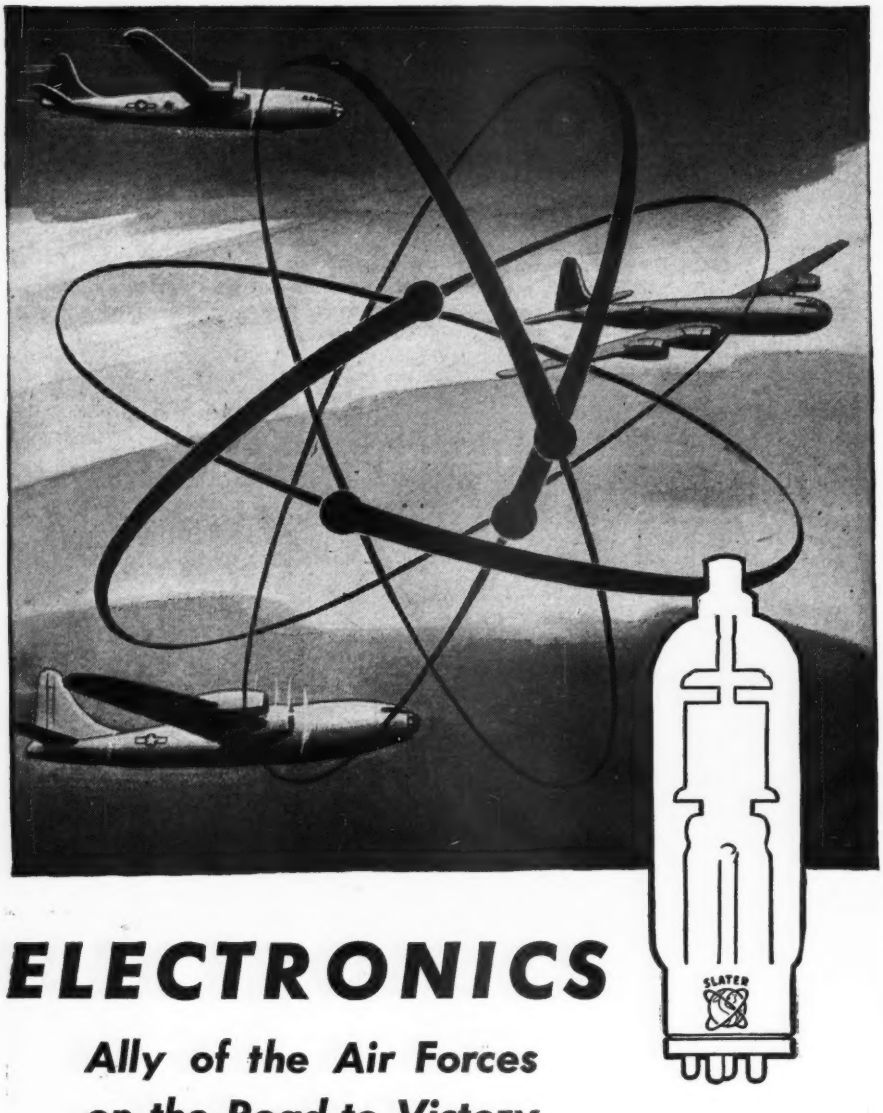

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• • •

Deficiencies of Group Hearing Aids

By Arthur G. Norris

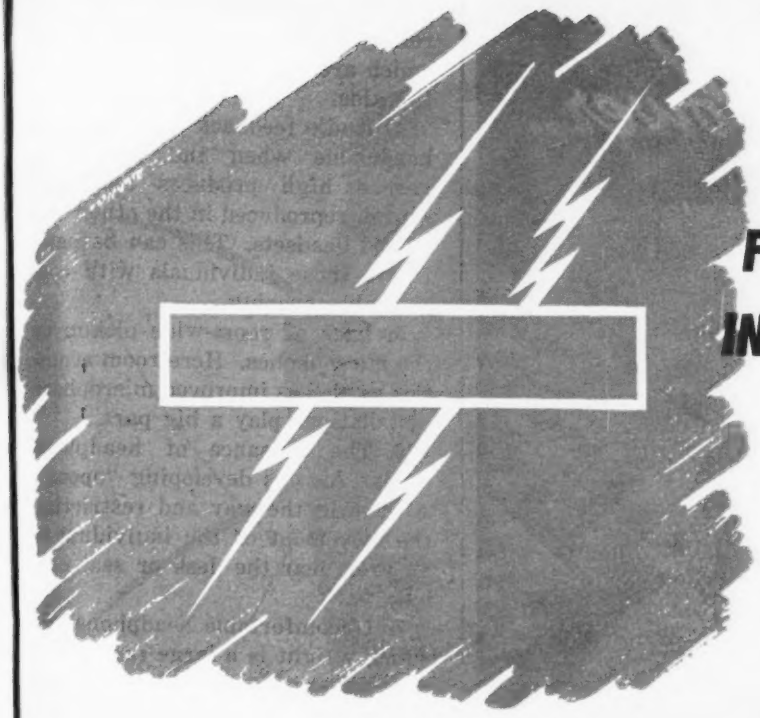
THE FIRST COMMERCIALLY produced group hearing aids were rather terrifying contraptions, full of knobs, wires and mystery, to say nothing of a frequency response which would not be tolerated in the cheapest radio today. The many wired appendages, complicated switching and volume control arrangements, and frequent failure of parts did nothing to alleviate the mystery and terror.

Refinement has been most apparent in the construction of parts for the sets and in their combination, but little attention has been paid to classroom utility. The present-day group hearing aids parallel closely the pattern set by the experimental sets built in the late 20's. Probably the reason for this has been that the makers of the group aids have never had to use them in a classroom full of squirming deaf youngsters. To the manufacturer, it has been a problem of high-fidelity amplification and there interest seemed to stop.

List of Defects

Most group hearing aids manufactured for classroom or auditorium use have one or more of the following defects which seriously interfere with optimum use of the equipment:

1. Over-simplification of amplifier design. Apparatus of this type is not a highly competitive product and is largely custom-built, hence there is little reason for taking the short-cuts which save pennies at the expense of precision and distortion-free output.
2. Inadequate tone control.
3. No arrangement to fit the amplifier output to the individual hearing pattern. In the present-day apparatus what is good for one



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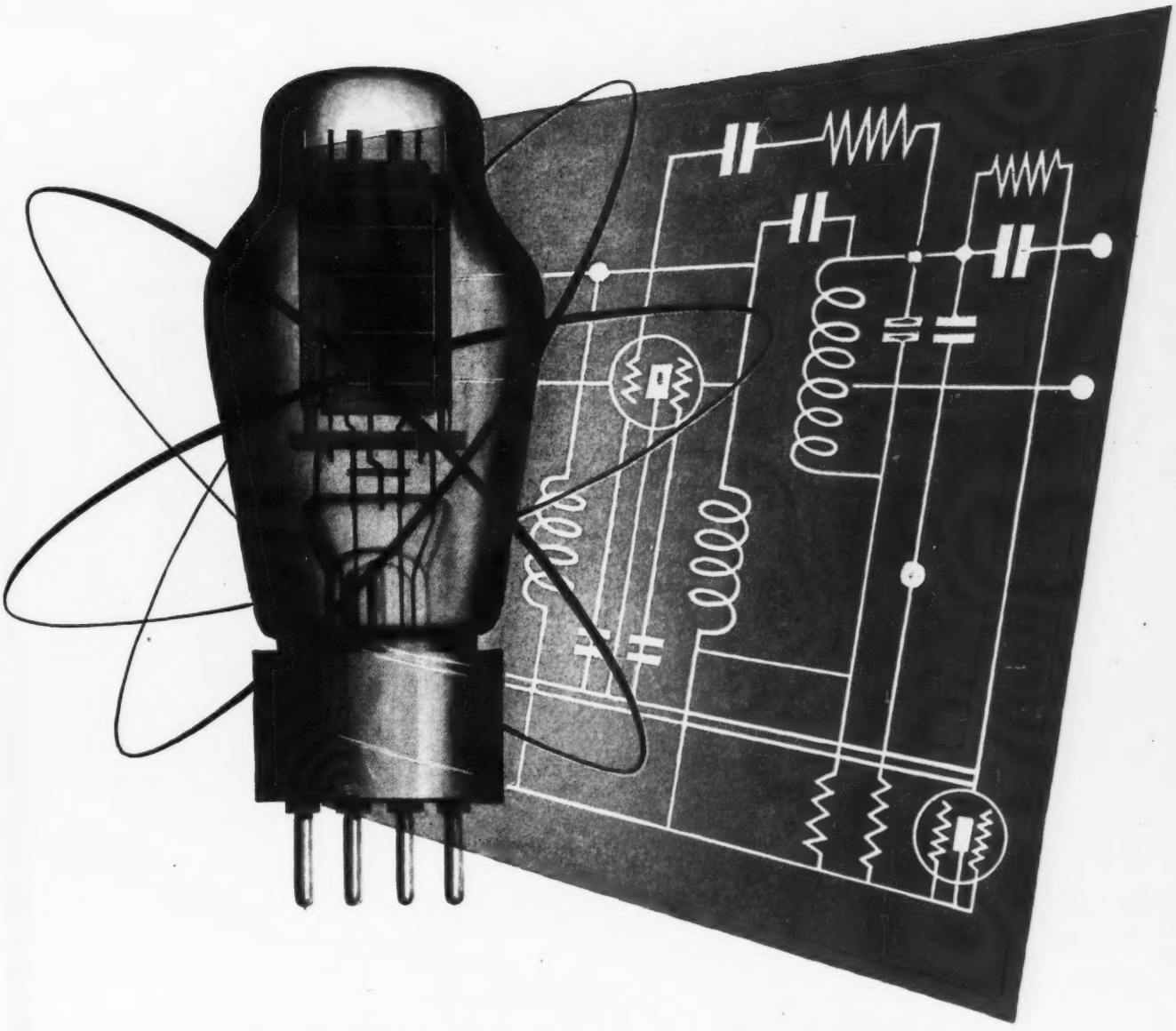

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must be good for all. This does not refer to individual volume controls which are found on all group hearing aids.

4. Audio feedback. An uncovered headphone when the volume is turned high produces an audio squeal, reproduced in the other connected headsets. This can be painful to those individuals with considerable hearing.

5. Lack of room-wide pickup by the microphones. Here room acoustics as well as improved microphone installations play a big part.

6. The nuisance of headphone cords. Always developing "opens". Always in the way and restricting the movement of the individual to an area near the desk or seat outlet.

7. Uncomfortable headphones, in which weight is a large factor.

8. Short-life individual volume controls. Unless one with normal hearing checks these at frequent intervals, the deafened person is apt to interpret the scratchiness of a deteriorating control as a part of the sound picture.

9. The installation difficulties of the wiring system for carrying the amplifier output to the individual outlets, and also the nuisance of the wiring system for the microphone input—cords all over the place.

10. Only a few commercial group aids designed for schoolroom use have provision for radio or phonograph input. This would be a desirable feature.

Some of the suggestions advanced will be considered impractical, but we believe they point a direction for future investigation. All of these defects cannot be brushed aside with one sweep of the pen. By calling attention to these shortcomings, and at the same time pointing a direction in which possible solution lies, we will have accomplished our aim.

Amplifier Design

The first objection, that of oversimplification of amplifier design, requires for correction greater study of amplifier components, better selection of parts, and a breaking away from the tendency to make one tube do the work of two. A few dollars added to the cost will make little difference.

The practice to date has been to cram the bass and treble control

"How about economical TOOLING for those STREAMLINED designs?"

Often, when designing a product for greater eye-appeal or improved utility, a coordination with efficient tooling is not given sufficient consideration. Result . . . slow production, high cost, competitive disadvantage.

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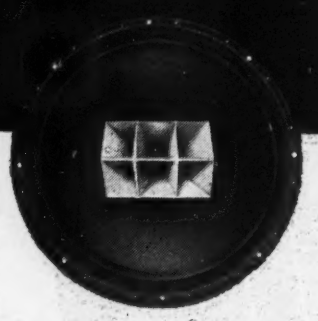

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into one unit. What is wrong with using two controls, one for bass and the other for treble? This gives greater flexibility and will give some measure of striking at the average need of the group.

No attempt is made today to fit the amplifier to the needs of the group as a whole. Present-day amplifiers just amplify within certain limits. If what comes out fits the listener, he is lucky.

Octave Control

Why not average the audiograms (graphic representations of hearing losses) of the individuals in the group in octave or half-octave steps over the speech range, setting a group of knobs on the amplifier to these averages, and thus obtain an amplifier output which more nearly approximates the needs of the group?

Some classification of the group of deafened individuals on a basis of hearing loss would assist in the solution of the problem. The writer has had constructed an amplifier with individual channel gain controls, one for each octave over a range of six octaves (128—4096 cycles) and with an overall gain control which brought the tuned pattern up to a level within the perception of even the most deafened. Such an arrangement is capable of elevating the valleys of the audiogram without disturbing the peaks at which the hearing is more nearly normal.

This problem could probably be solved more effectively, if instead of one master amplifier for the group, smaller, individually adjusted amplifiers were constructed. This might be worked out on a basis of secondary stage amplification after overall pre-amplification, thereby making the individual amplifiers smaller.

Feedback Problem

Audio feedback in the classroom amplifier is one of the most discouraging elements in the use of the group hearing aid. With a sensitive microphone and the amplifier volume turned up high, an uncovered or poorly fitted earpiece will produce very objectionable audio feedback. The elimination of this deterrent to a full use of the group hearing aid should not be too difficult or too expensive. Audio

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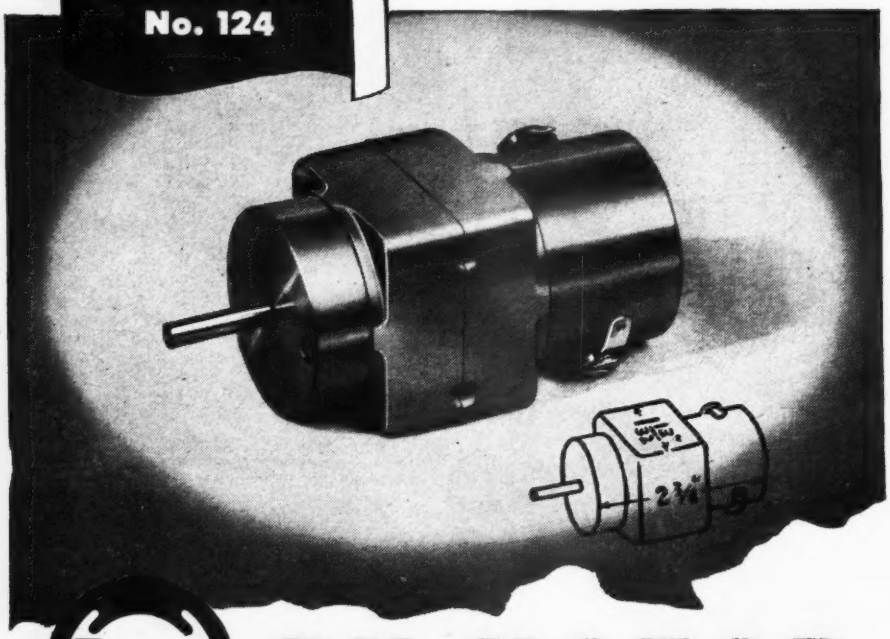
No. 124



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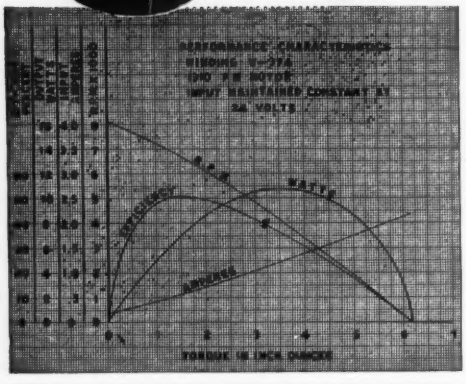
Torque 3.5 in. oz. at 4500 RPM



Unique in design and construction, this permanent magnet field motor has been selected for many applications having critical space and weight factors. Wound as a shunt motor, its output characteristics are adaptable for a wide variety of power requirements.

PM MOTOR — 1310		
Watts Output Int.	(max.)	11
Torque at 7000 RPM	(in. oz.)	1
Torque at 4500 RPM	(in. oz.)	3.5
Lock Torque	(in. oz.)	6
Volts Input	(min.)	5
Volts Input	(max.)	32
Temperature Rise Int.		50°C
Weight		11 oz.
Shaft Diameter	(max.)	.250"
Length less Shaft		2¾"
Overall Diameter		1 13/32"

FEATURES

ELECTRICAL

- Alnico field magnets
- No field losses
- Low starting current
- Reversible with change of polarity
- Low RF interference
- Armature windings varnish impregnated and baked

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- Completely enclosed
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feedback, being a function of circuit dimensions and room acoustics and occurring at a frequency usually well above the speech range, might readily be controlled by a tuned crystal circuit responsive only to the frequency band of the feedback. Other circuit refinements, such as separate high-voltage power supplies for each stage of amplification, would assist in reduction of this trouble.

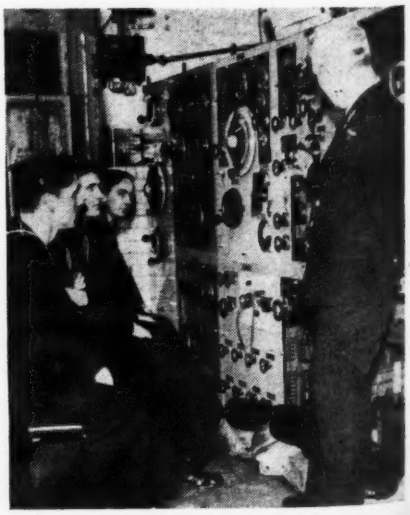
Most commercially made group hearing aids in use today have microphones which are highly sensitive, but they still leave much to be desired in the matter of picking up faint voices in the back of the room. Schoolroom use of the hearing aid requires that the children be able to hear their own voices as well as that of the teacher. To do this the microphone must be of high quality and must be nondirectional. Placement of the microphone in the room has considerable bearing on the problem. In general, the greater the microphone sensitivity, the greater the trouble with audio feedback, but with the elimination of the feedback or the boosting of it to inaudible frequencies, better microphones could be used.

Cords

Until it is possible to produce non-twistable, non-kinkable cords,

• • •

RADIO SEA CADETS



Sea Cadets join the British Royal Navy at the age of 17 to be trained as signalmen and telegraphists. In the photo above, cadets are receiving instruction on a high-power transmitter at H.M. Signal School

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OUTPUT CURRENT – 500 MA Max
This model suitable for use in place of A Batteries where a source of AC power is available

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General purpose supply which will deliver well-regulated DC at any voltage from 0-300

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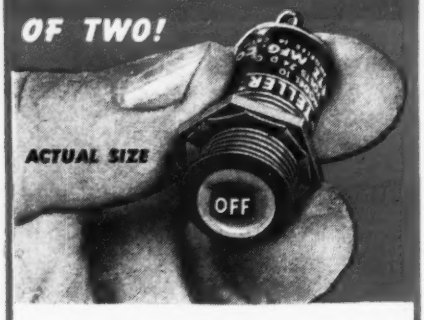

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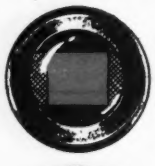

WARNING
Indicates warning or signal function of circuit. "TELLER" energized.

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Reveals circuit failure or power interruption. "TELLER" not energized.

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Indicates circuit integrity. "TELLER" energized.

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Weight	.64 oz.
Voltage	18-30 dc
Wattage	1.2
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Altitude	0-50,000 ft.

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Los Angeles 34, California

this part of the equipment is going to cause more than its proportionate share of trouble. Perhaps some sort of a double swivel tip would do the work—one at each end of the cord. Or, instead of the somewhat rigid cord of today, something completely "soft" might be used. A very soft cord might not kink so badly—perhaps something like a soft braided silk rope.

Headphones are too heavy. The crystal type of phone is an advance over the magnetic type as far as weight is concerned, but it is still unwieldy. Individual hearing aids show considerable progress made in the direction of weight and size reduction of the earpiece. It should not be too difficult to effect a better seal at the ear and thus make it possible to reduce the diaphragm size without loss of efficiency.

Any scheme of room wiring developed up to now has been cumbersome. It is necessary to wire power to the amplifier, wire the microphone input to the amplifier, and wire the output of the amplifier to the various headsets. There might be substituted a system of radio transmission. Would it be feasible to use a vhf transmitter and equip each desk with a battery-powered receiver with adequate gain and tuned to the individual user? Instead of batteries as a source of power an inductive power pickup might be arranged, but again the wiring necessary for this arrangement might offset the advantages gained.

Ideal System

These suggestions are not so fanciful as they may seem. Preliminary experiments have given rise to the belief that many of the troubles enumerated can be eliminated when it again becomes possible to produce instruments of this type.

The ideal post-war group hearing aid should have most, if not all of the following characteristics:

1. High, distortionless gain to amplify even the faintest sounds.
2. Ultra-sensitive, nondirectional microphones capable of covering the entire room area.
3. Freedom from audio feedback.
4. Adjustability to individual hearing patterns.
5. Freedom of movement about

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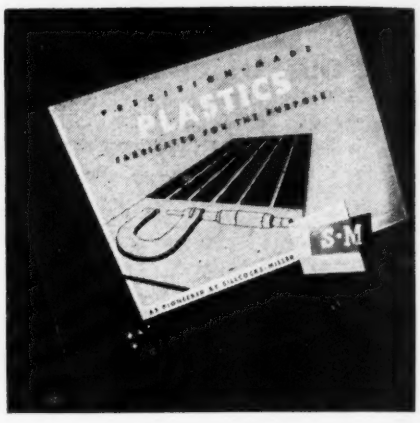

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Reproduced above is an actual photograph of a "light" method frequency pattern. The inside, the wide midway and the outside band are 1,000 cycle reference bands. Starting at 1,500 cycles, at the midway reference band, the succeeding outward bands increase by 500-cycle increments to 8,000 cycles.

Measurements by standard formula will show that all variations in frequency strength are within ± 2 db.

Narrowing frequency bands, from 1,000 down to 50 cycles in the bass, indicate a controlled power decrease — by means of a "network" in the electrical circuit of the Fairchild Magnetic Cutterhead.

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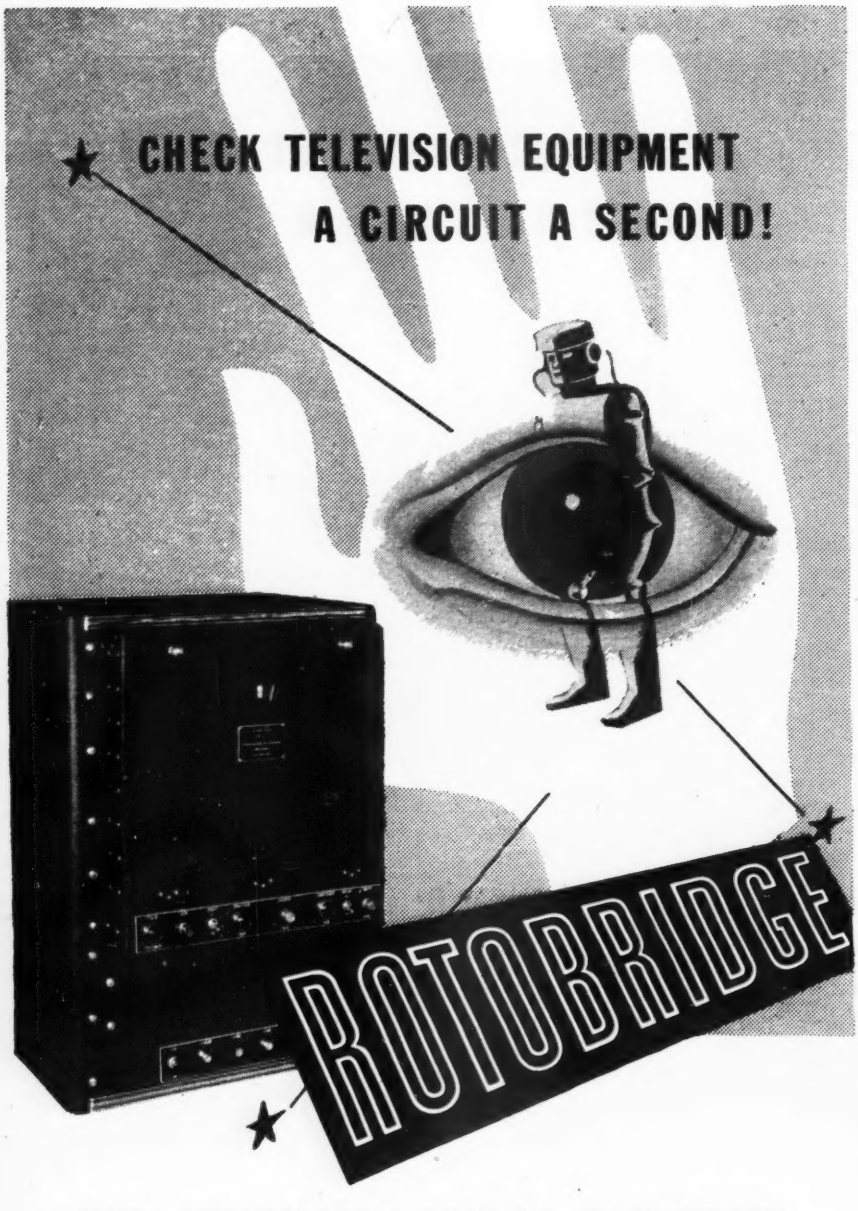

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the room for the user.

6. Adequate output.

7. Freedom from wiring impediments.

8. Phono input or a phono turntable built integrally with the amplifier.

9. Installations should be tailored to fit the classrooms where they are to be used. One all-purpose installation will not suffice.

Speech improvement of deaf children goes hand in hand with utilization of partial hearing via the hearing aid. Here the group hearing aid can be augmented by the use of a visual aid as well as the use of amplified speech as a teaching medium. A ladder-type neon tube operating from the amplifier output can be used to improve volume and inflection. Such a tube has been experimentally constructed using a series of spaced electrodes inserted into a straight length of tubing. Using a resistor network, the light column can be made to rise and fall according to the speech inflection. Vowel sounds can be calibrated on the tube in terms of levels—each pure vowel sound to produce a column of light of a different length. This speech-teaching device should be a part of each post-war group hearing aid.

• • •

ELECTRONIC STETHOSCOPE

High-pitched body tones are accentuated and tones of lower pitch are subdued by the Stethetron, an electronic stethoscope. Lieutenant Rafael Morales, physician at the Military Hospital in Havana, Cuba, tries the instrument on Evelyn Dobson, model

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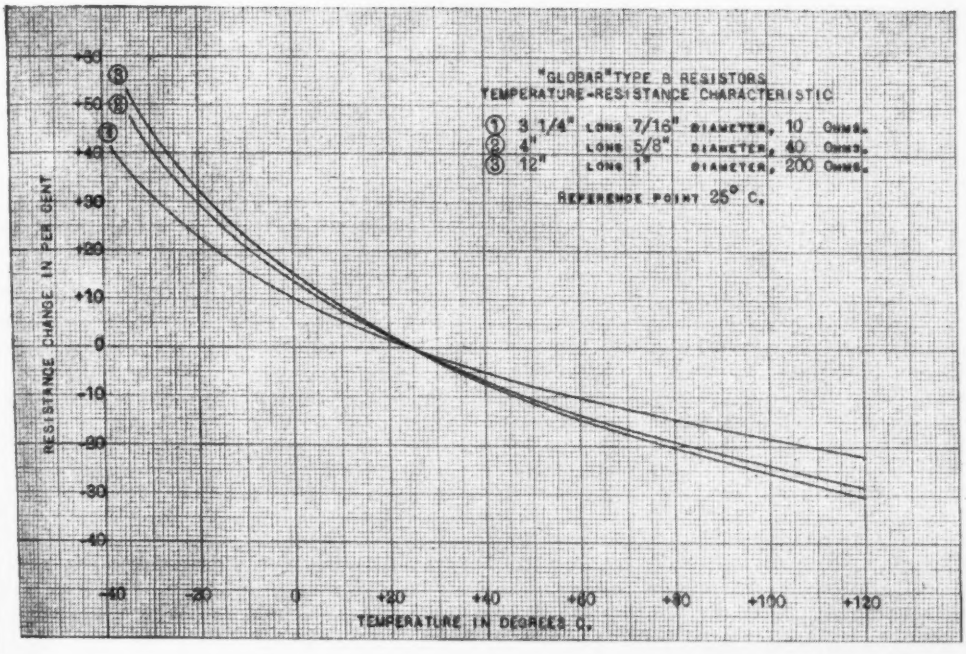

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Resistors like those illustrated are not to be found in catalogs, as they are made to cover special problems. It is essential that complete information such as:

1. Operating temperature range of the apparatus.
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4. Space limitations.
5. Whether the resistor will be closely confined or mounted in the open.

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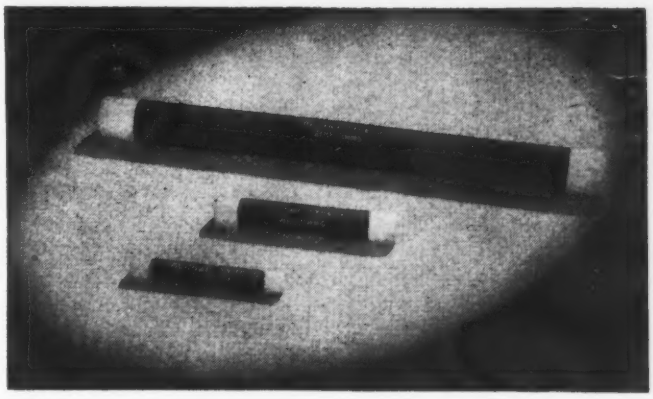

Resistors for applications requiring more pronounced characteristics are also available. Working samples for engineering tests will be furnished if required. The Carborundum Company, Niagara Falls, N. Y.

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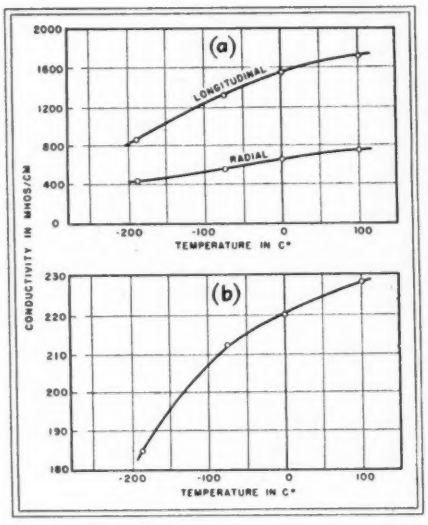
THE ELECTRON ART

Low-Temperature Conductivity 286
Acoustics of Small Rooms and Studios 286
Resonant Circuit Response to F-M Signal 304
Laplace Transforms for the Electronic Engineer 304
Parabolic Graph Paper for Square-Law Functions 314

Low-Temperature Conductivity

THERMAL AND ELECTRICAL conductivity of graphite and carbon at low temperatures are discussed by R. A. Buerschaper in the *Journal of Applied Physics* for May, 1944. Electrical conductivity obtained from laboratory measurements is given in the accompanying graphs. The tests were conducted on Acheson graphite electrodes cut into rods along the electrode axis, and along the radius, and on carbon electrodes, both supplied by the National Carbon Co.

These measurements agree at 0 deg C with those of Powell and Schofield (*Proc. Phys. Soc.*, **51**, p. 153-172) who measured the conductivity of graphite and carbon at temperatures from 100 deg C to 2500 deg C.



(a) Electrical conductivity of graphite vs temperature. (b) Electrical conductivity of carbon vs temperature

Acoustics of Small Rooms and Studios

INFORMATION OF VALUE, both for small studio design and in understanding the limitations imposed on final reproduction by the listener's room, is contained in a paper by J. Moir in *Wireless World* (Dorset House, Stamford St., London, S.E.I., England) for November, 1944.

Small-room reproduction, to be comparable to concert-hall performance, must produce the same instantaneous and spatial acoustic pattern. To determine how closely this goal could be reached, theoretical analyses of other investigators were compared with data taken in the room shown in Fig. 1.

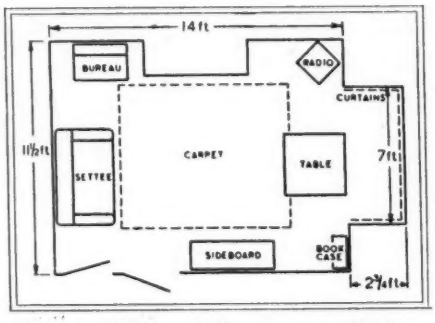


Fig. 1—Walls of this room used for acoustic measurements were distempered and the floor was covered with linoleum

Reverberation Time

Sabine concluded from investigation of acoustics of rooms that the primary factor was the time taken for room boundaries to absorb the sound energy after cessation of the initial sound. He defined reverberation time as that period taken for the average sound energy to decay to −60 db below its initial value, and developed empirical equations from which reverberation time of a room could be calculated.

Average sound energy in a room grows exponentially, from the instant the sound source commences, in accordance with the equation $P = (4E/cS\alpha)\ (1-\epsilon^{-cS\alpha t/4V})$ where P is the sound energy density, E is the rate of emission of the source, c the velocity of sound, S the total surface area, α the average absorption coefficient, and V is the room volume. Steady state is reached when the energy is uniformly distributed throughout the room. The room boundaries are then absorbing energy at the same rate that it is being produced.

Similarly, when the sound source ceases, the average sound energy density decays exponentially as given by the equation $P = (4E/cS\alpha)\epsilon^{-cS\alpha t/4V}$.

Figure 2 shows how reverberation time affects intelligibility. Speech and music consist of series of syllables or phrases separated by well defined intervals of silence. If the decay rate of the room is so slow that energy from successive syllables overlaps, lack of intelligibility results. If reverberation time is short, each syllable stands alone and is readily understood.

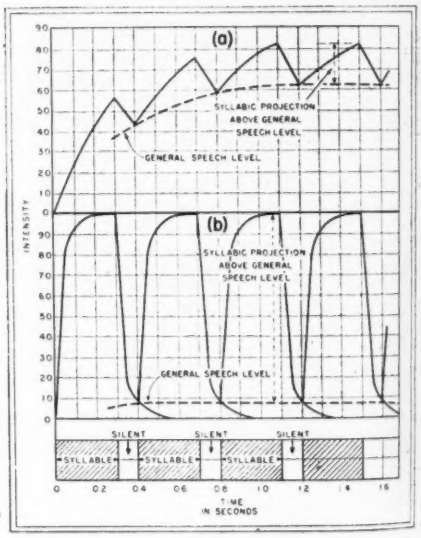


Fig. 2—Growth and decay of sound in a room (a) of 5 sec reverberation time, and (b) of 0.5 sec reverberation time show the general speech level and the syllabic projection above that level

Optimum Reverberation Time

Subjective tests show that very short reverberation times give a dull, lifeless effect to sounds, probably as a result of our long experience listening in rooms having ap-

The official caption of this official Navy Photo reads, "Top flight radio operators plus top flight equipment equals top flight performance at an African clearing base for the Italian Front."

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preciable reverberation times. Subjectively determined optimum reverberation time for rooms of various volumes are given in Fig. 3.

Theory has little to say about optimum reverberation time, although it does predict that for rooms of comparable dimensions those for reproduced music should have shorter reverberation times than those for live production of the same class of music because the reproduced music will contain the reverberant sound of the production studio.

Sabine gives for reverberation time the empirical equation $T = 0.05V/S\alpha$. The most convenient control of this time is through the absorption coefficient. Absorption co-

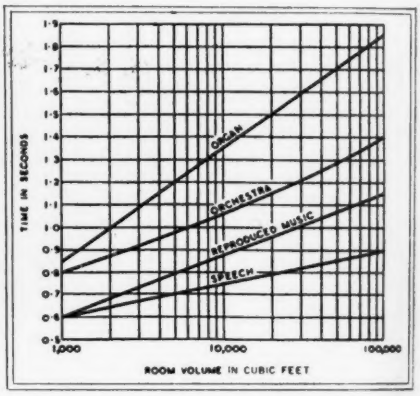

Fig. 3—Subjectively determined optimum reverberation times for different types of sound in various sizes of rooms

efficient expresses the effectiveness of a material in absorbing incident sound. For hard rigid material, α is low; for soft porous material, it approaches unity. Figure 4 presents some of the available data on absorption coefficients of material common in domestic architecture. It will be seen that sound absorption varies with frequency.

Theoretical work of Knudson and McNair suggests that optimum reverberation time should change with frequency as shown in Fig. 5. Experience substantiates this theory, except above 3 kc where a gradual fall with increasing frequency of reverberation time appears more acceptable.

Measurements in the room of Fig. 1 show the reverberation time vs frequency of the measured curve in Fig. 5. It will be seen that the observed reverbation time is below the optimum time. Some of the absorbent material such as chairs and carpet was removed but this did not

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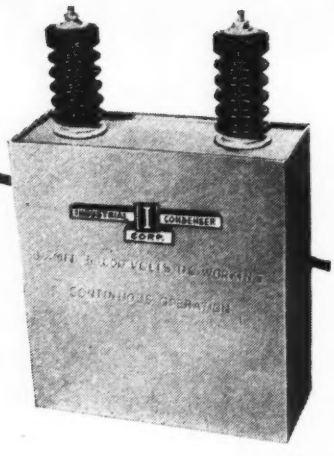

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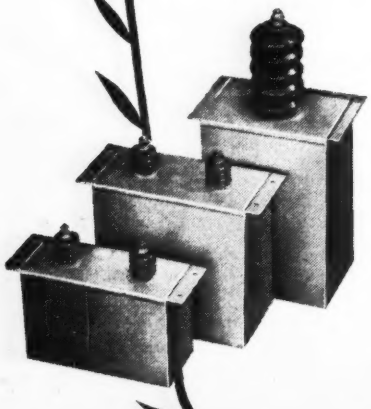

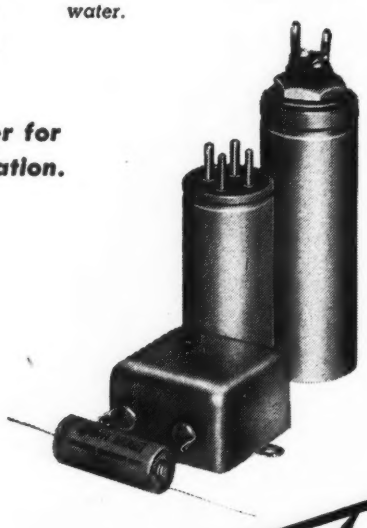

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increase the reverberation time to the optimum.

Wall Vibration

The absorption curve of Fig. 4 indicates that the reverberation time should measure longer at low frequencies than at high. This was not the case, as is shown in Fig. 5, because of absorption by vibration of the room structure.

The physical properties of floors, walls and ceilings absorb the sound energy required to produce and maintain their vibration, the energy being dissipated in internal friction. In addition, building elements have resonant frequencies, especially at low frequencies. At these frequencies, they absorb and dissipate many times the energy they absorb well off resonance. Thus non-porous surfaces which would have low absorption if rigid, have high absorption at some low frequency where they are resonant. Increasing the mass of the surface will place this frequency below the audible range, although, the usual domestic construction is such as to provide excellent vibrating absorbers in the lower audible register. The result is the bass-deficient measured characteristic rather than the optimum reverberation time vs frequency characteristic of Fig. 5.

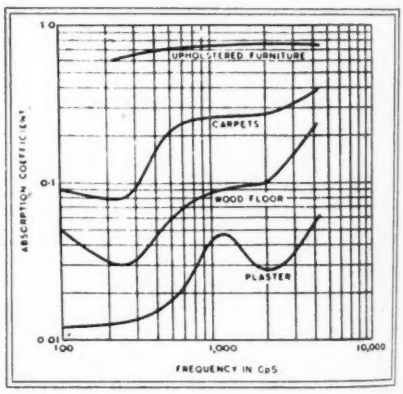
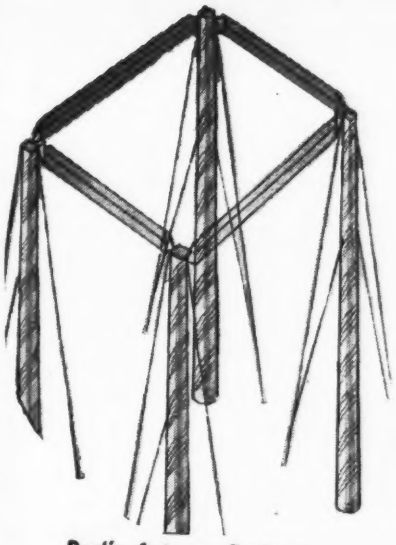


Fig. 4—Absorption coefficients of typical domestic surface materials

The direct effect of this deficiency is an obvious lack of bass because sound intensity in an enclosure is almost directly proportional to reverberation time. This lack of bass cannot be completely corrected by increasing the bass output of the loudspeaker, although it may be partially corrected in this manner. The subtle difference is that reverberation adds coloration to the di-



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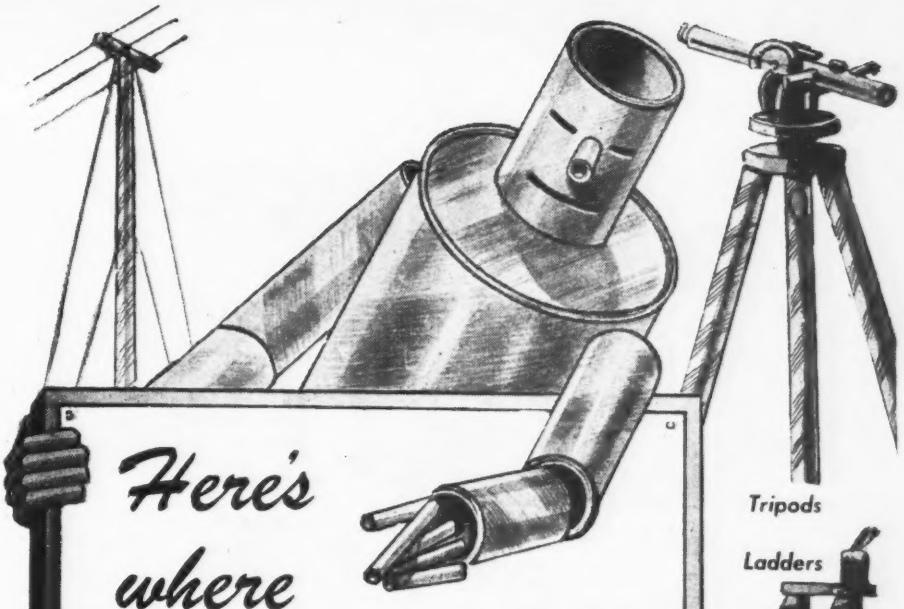

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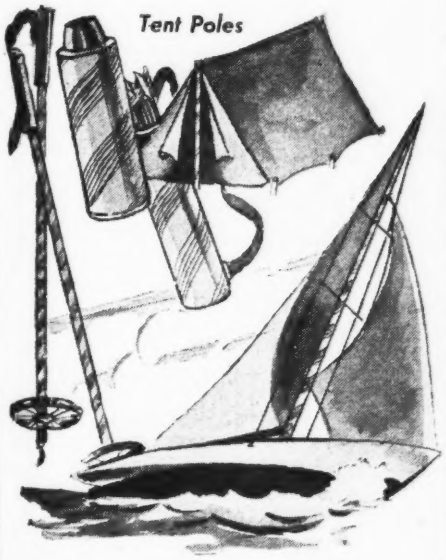

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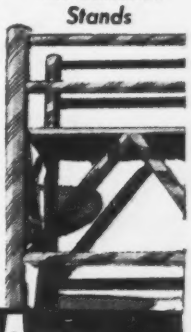

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rect sound by adding components which persist after the original has ceased, while an increase in bass loudspeaker output merely increases the direct sound intensity. Listening experience in comparable rooms having reverberation characteristics similar to the two curves of Fig. 5 suggests that this point is of more than academic interest.

Wall and Room Resonance

Vibrating surfaces may reinforce the reproduced sound at the resonant frequency of the partition. For example, mechanical coupling through the cabinet from loudspeaker to floor can greatly increase radiating efficiency at the resonant frequency of the immediate section of flooring. If the effect is objectionable, it can be reduced by placing loaded isolating pads beneath the cabinet.

The reverberation time at a particular frequency may be effectively increased if the vibrating partition

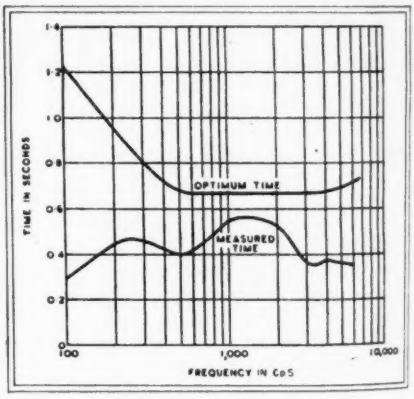

Fig. 5—Optimum and measured reverberation times for the room of Fig. 1 as a function of frequency

has a slower rate of decay than the room, with the result that the partition returns energy at its resonant frequency to the room after normal room vibration has ceased. If the returned energy was at the frequency of the incident energy, the effect would only be to increase the decay time, but transient sound having frequency components near partition resonance or harmonically related frequencies will produce reverberation at the resonant frequency of the partition. This re-radiated energy, having been translated in frequency by the partition, may be discordant unless of very low intensity compared to the fun-

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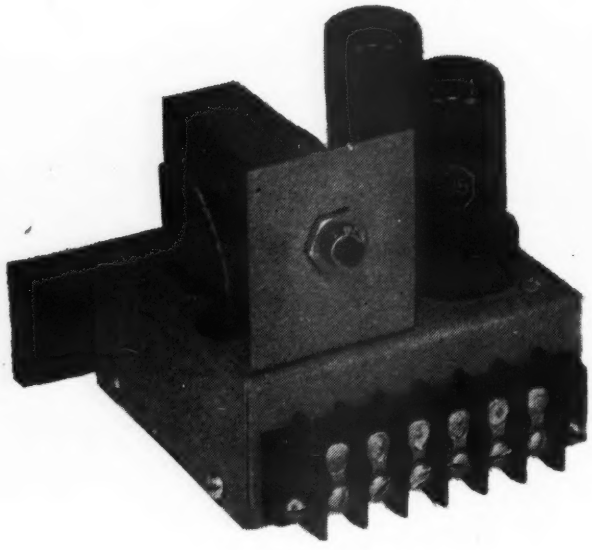

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damental of the original sound.

A small room, having dimensions comparable to a wavelength at the bass frequencies, also has resonances similar to those of a stopped organ pipe. Lord Rayleigh derived the expression for these frequencies for three-dimensional space as $f = (c/2)\sqrt{(A/L)^2 + (B/W)^2 + (D/H)^2}$, where L is length, W width, H is height, and A, B, D are integers 0, 1, 2, 3, etc. From this equation it is seen that a small room can have an anharmonically related series of peaks in its frequency characteristic. The effect of these partition and room resonances may be such as to increase a 5-percent harmonic in the electrical system to a 50-percent harmonic in the final reproduced sound.

Mean Free Path

Because of the change of reverberation time with frequency, the concept of an optimum reverberation time is of dubious value when applied to small rooms. If the mean free path ($4V/S$) of the room is considered, it will be realized that in a small room there are more reflections with their attendent modification of the intensity and relative frequency component of the sound per second than in a large room or auditorium.

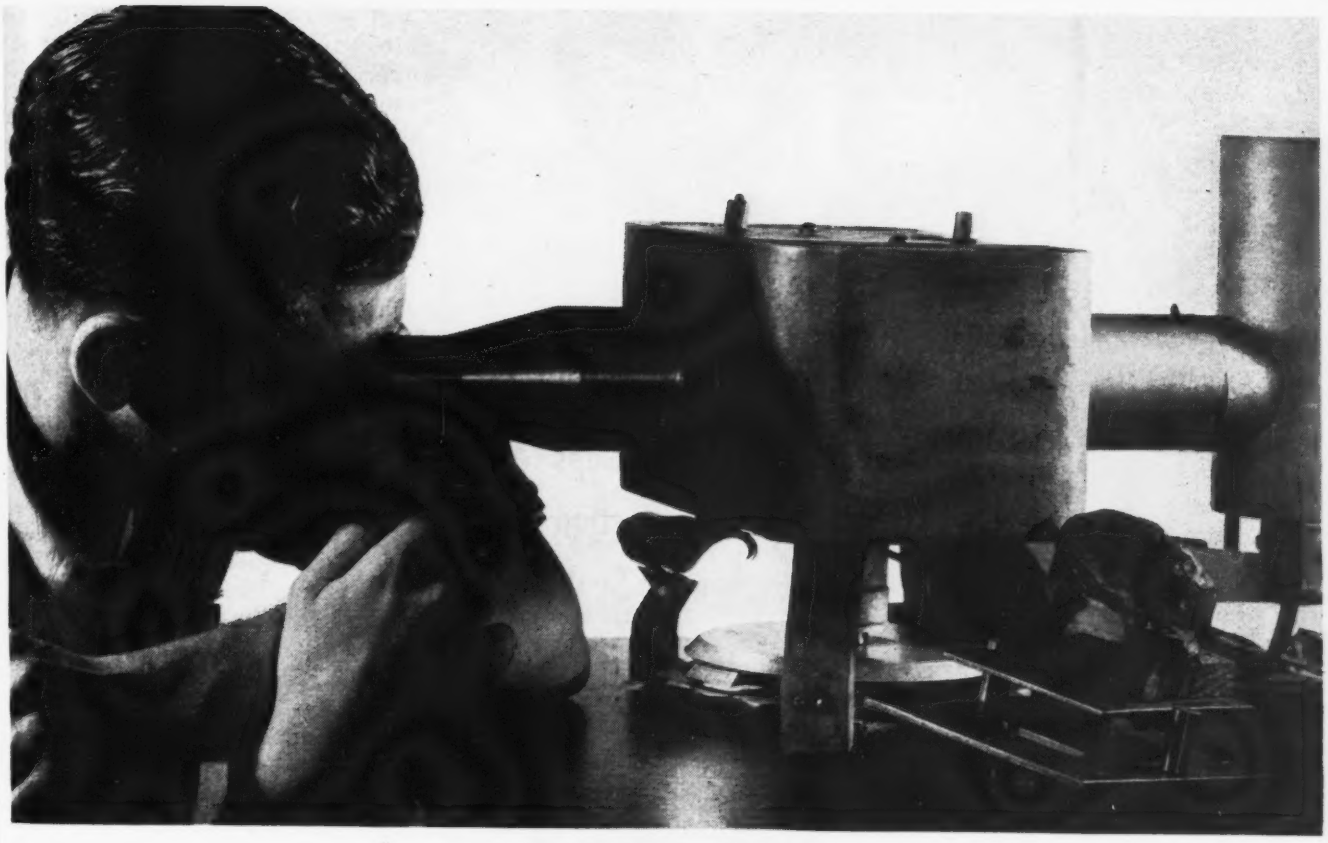
Our main impression of quality is probably formed in the first 250 milliseconds. Thus in a smaller room, where a larger number of reflections takes place during this impression-forming period, there is far greater opportunity for the room to impose its characteristics upon the sound than in a larger room.

A comparison of the same program reproduced in the room of Fig. 1 and in a motion-picture theater indicates that the reproduction in the theater was preferable, although the electrical characteristics of the domestic installation were superior.

From these observations it is evi-

—◇—

RADIO RECEPTION is best immediately before and at the time of a full moon and varies with the phases of the moon, according to Dr. Harlan T. Stetson, director of the laboratory for cosmic terrestial research of MIT.



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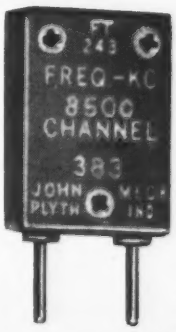

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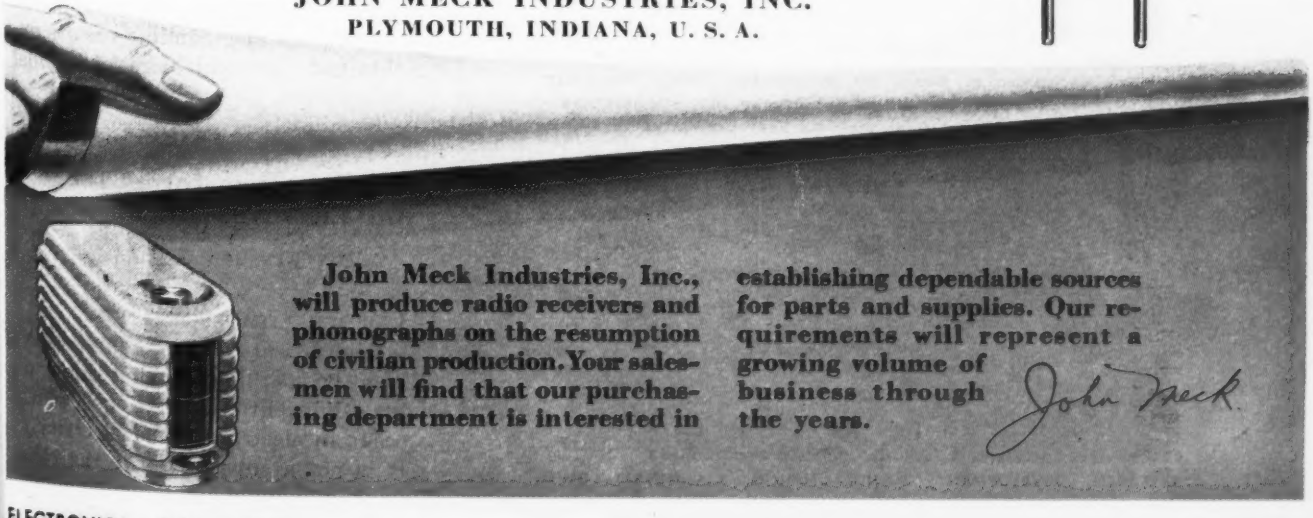

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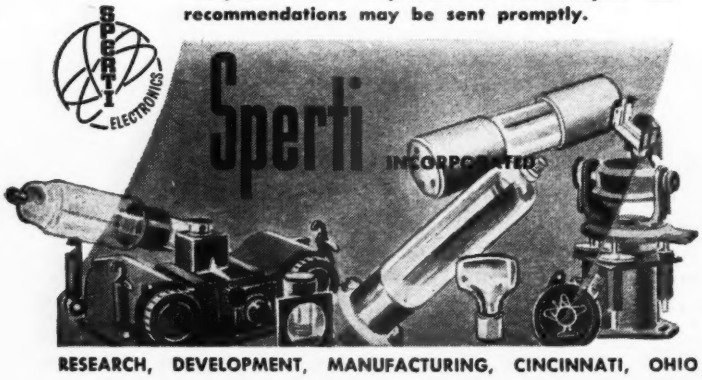

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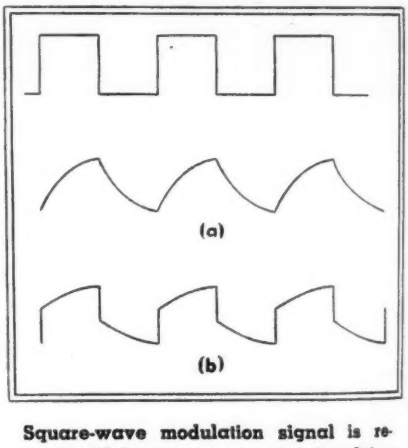
dent that in small rooms quality reproduction of low notes is the most difficult, and that—because of accumulated experience listening in large halls—small-room reproduction does not fit our concept of quality. However, the position is rapidly changing to one in which a high percentage of our listening is done in small rooms and our standards of good quality may undergo a gradual change.

• • •

Resonant Circuit Response to F-M Signal

TRANSIENT RESPONSE of an RLC parallel resonant circuit to amplitude and frequency-modulation signals is analyzed by operational methods by D. A. Bell in the March, 1944 *Philosophical Magazine* (Red Lion Ct., Fleet St., E.C. 4, London, England). For a modulation band-



Square-wave modulation signal is reproduced by an a-m system involving a resonant circuit as at (a), and by an f-m system containing the same resonant circuit as at (b)

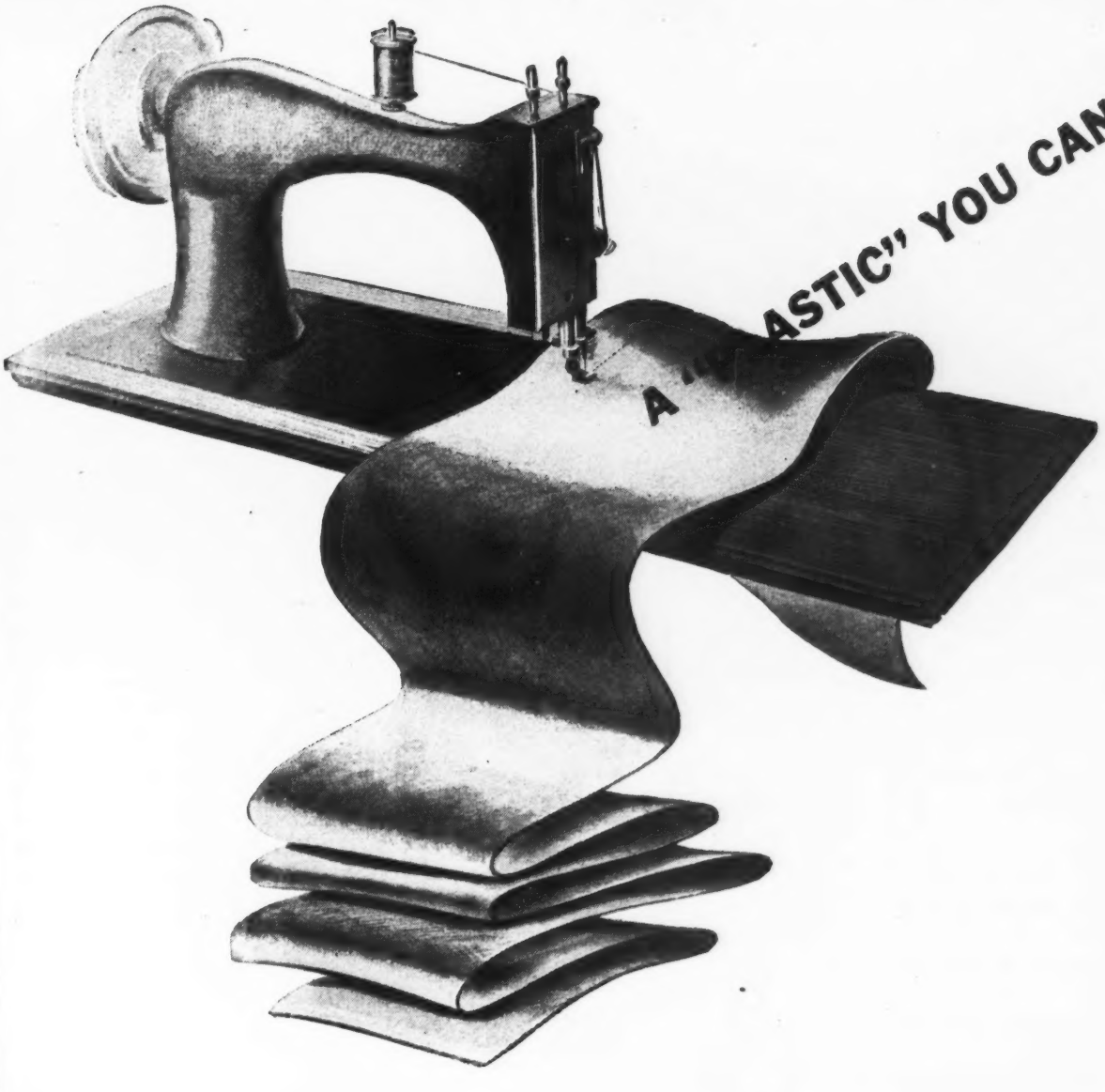
width which is large compared with the circuit bandwidth, the response of a system in which all elements but the parallel resonant circuit are linear is shown in the accompanying illustration. Similar results are obtained for wideband sinusoidal modulation.

• • •

Laplace Transforms for the Electronic Engineer

BY GERSHON J. WHEELER

LAPLACE TRANSFORMATION is a mathematical device that is extremely useful in solving many of the differential equations which occur in electronics and electricity. It is not a substitute for the clas-



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sical method of solving these equations, but rather an additional tool for the engineer. Briefly, it is a means of transforming a differential equation into what might be called an equivalent algebraic equation which can be solved in a straightforward manner.

This article will discuss how this transformation may be used, but will make no attempt to explain why it works. This approach is contrary to sound mathematical procedure, but it is practical.

Before tackling a differential equation by this method, it is necessary for one to know the algebraic equivalent of each function in the equation. This algebraic equivalent is known as the Laplace transform of the function. The more common Laplace transform pairs, the function and its transform, and some elementary properties are included in the table below. In each case t is the independent variable.

Referring to the table of transforms, from (4) it is plain that the transform of t is $1/p^2$ and of $t^2/2$ is $1/p^3$. From (13) one can see that $7t^2/2$ will have a transform 7 times that of $t^2/2$, namely $7/p^3$. From

SHORT TABLE OF LAPLACE TRANSFORMS

	Function	Transform
1	1 (unity)	$1/p$
2	x	$\overline{x}$
3	K	K/p
4	$\frac{t^{n-1}}{n-1}$	$1/p^n$
5	ϵ^{at}	$1/(p-a)$
6	dx/dt	$p\overline{x} - x_0$
7	d^2x/dt^2	$p^2\overline{x} - px_0 - x_1$
8	$\sin \omega t$	$\omega/(p^2+\omega^2)$
9	$\cos \omega t$	$p/(p^2+\omega^2)$
10	$\sinh \omega t$	$\omega/(p^2-\omega^2)$
11	$\cosh \omega t$	$p/(p^2-\omega^2)$
12	$\frac{1}{(p+a)(p-b)}$	$\frac{\epsilon^{-at} - \epsilon^{-bt}}{b-a}$
13	$Kf(x)$	$K\overline{f}(x)$
14	$f(t-T)$	$\overline{f}(p)\ \epsilon^{-pT}$
15	$f(t)\ \epsilon^{Kt}$	$\overline{f}(p-K)$

where
x = any variable dependent upon t
K = a constant
x_0 = initial value of x
x_1 = initial value of dx/dt
T = initial value of t

(14), the transform of $t-a$ is the same as the transform to t multiplied by ϵ^{-ap}, or $(1/p)\epsilon^{-ap}$. Since $\omega/(p^2+\omega^2)$ is the transform of $\sin \omega t$, then from (15) $\omega/[(p-a)^2+\omega^2]$ is the transform of $\epsilon^{at} \sin \omega t$.

If a fixed voltage E is applied to a series circuit comprising an inductance L and a resistance R, what is the current as a function of time? The differential equation for the circuit is

$$E = L\,(di/dt) + Ri$$

or

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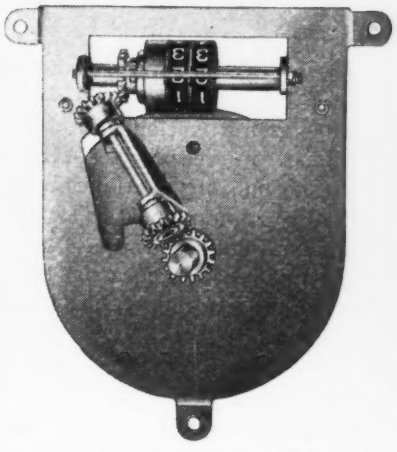
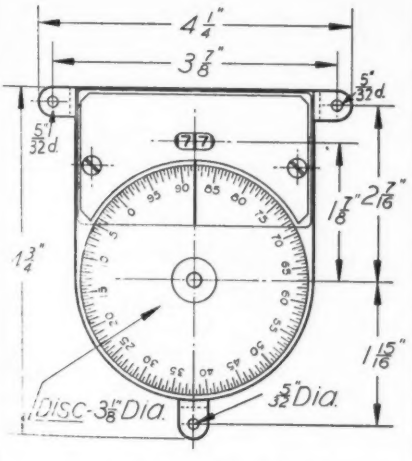
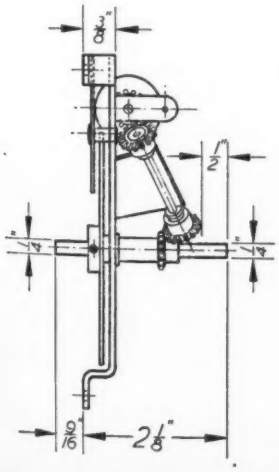


Rear view construction of Techrad Interpolating Counterdial



Front and side dimensions of Techrad Interpolating Counterdial



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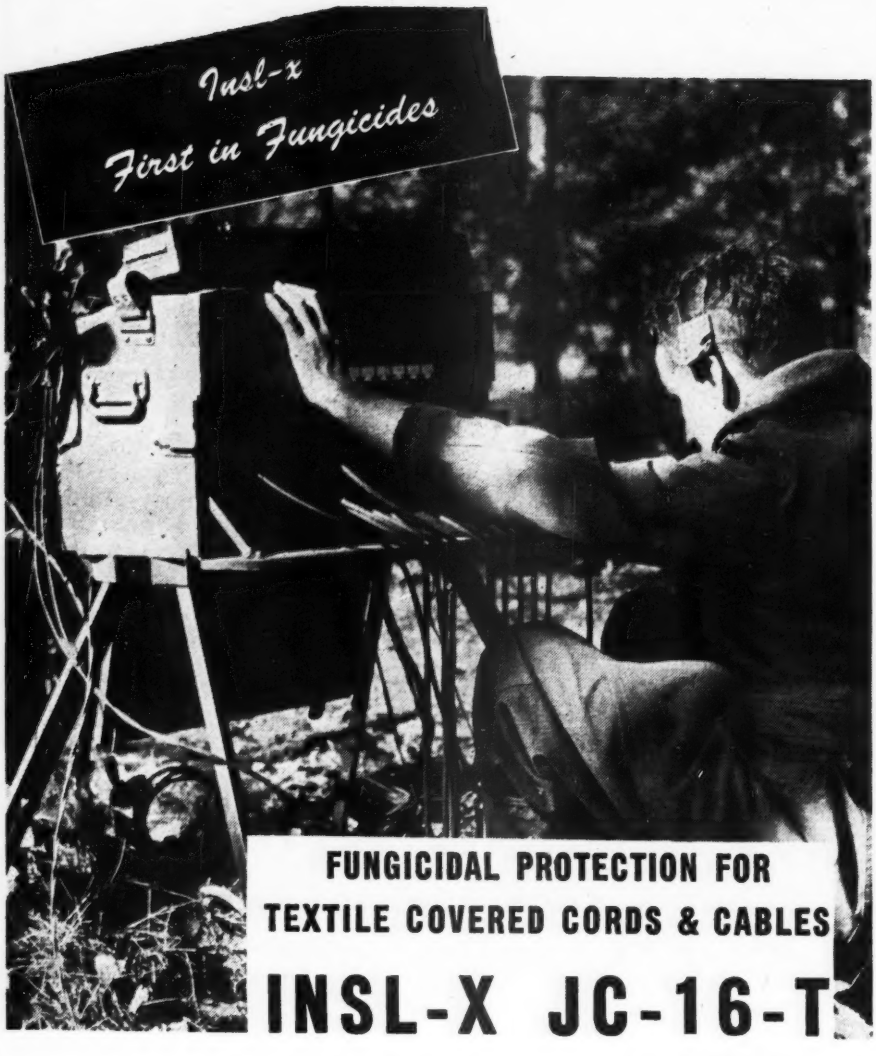

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★ Provides complete protection against moisture and fungus on all textile covered cords and cables used on Signal Corps equipment.

★ NON-TOXIC TO HUMANS—*official tests show INSL-X will not cause dermatitis.*

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$(E/L) = (\mathrm{d}i/\mathrm{d}t) + (R/L)\,i$

To solve this equation by Laplace transformation the first step is to replace each term by its transform.

From the table, the transform of $\mathrm{d}i/\mathrm{d}t$ by (6) is $p\bar{\imath} - i_0$ of $(R/L)i$ by (2) and (13) is $(R/L)\bar{\imath}$, and of E/L by (3) is E/pL. Thus the new algebraic equation is

$$(E/pL) = pi_0 + (R/L)\,\bar{\imath}$$

This equation is solved for $\bar{\imath}$, giving

$$\bar{\imath} = [E/pL\,(p + R/L)] + [i_0/(p + R/L)]$$

The process is reversed and each term in the last equation is replaced by its time function. To do this easily, it is necessary to break the larger terms into partial fractions. This operation is not difficult and methods of doing it can be found in a second year algebra book. Expressed in partial fractions the equation is

$$\bar{\imath} = E/R[(1/p) - 1/(p + R/L)] + [i_0/(p + R/L)]$$

Referring again to the table, from (2) $\bar{\imath}$ is the transform of i, from (3) E/Rp is the transform of E/R, and from (3) and (15) $[E/R]\,[1/(p + R/L)]$ is the transform of $(E/R)\epsilon^{-Rt/L}$, and $i_0[1/(p + R/L)]$ is the transform of $i_0\epsilon^{-Rt/L}$. Making these substitutions

$$i = (E/R) - (E/R)\epsilon^{-Rt/L} + i_0\epsilon^{-Rt/L}$$

This is the required solution. If, as is usually the case, $i = 0$ when $t = 0$, there is no i_0 term and the transform of $\mathrm{d}i/\mathrm{d}t$ is simply pi.

Circuit Response to Sinusoidal Voltage

Suppose that the voltage applied to the same circuit is $E\sin\omega t$, and we desire to find the current as a function of time. The equation is

$$E\sin\omega t = L\,(\mathrm{d}i/\mathrm{d}t) + Ri$$

or

$$(E/L)\sin\omega t = (\mathrm{d}i/\mathrm{d}t) + (R/L)\,i$$

Transforming as before and assuming that $i_0 = 0$ we obtain

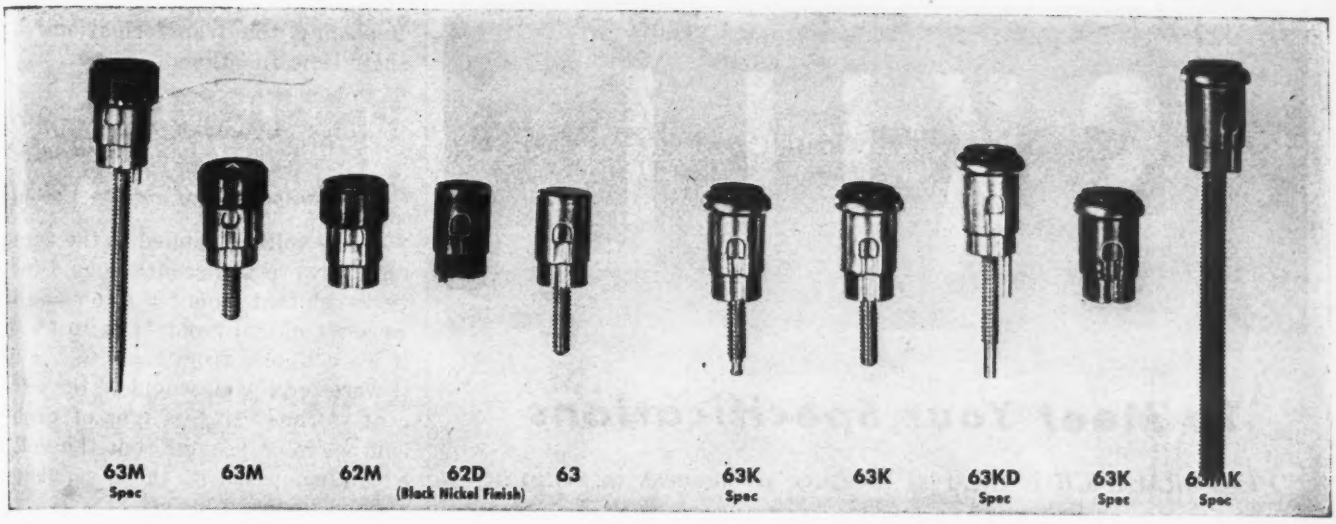
$$p\bar{\imath} + (R/L)\bar{\imath} = (E/L)\,(\omega/p^2 + \omega^2)$$

This equation is solved for $\bar{\imath}$ and separated into partial fractions.

$$\bar{\imath} = \left[\frac{E}{L}\right]\left[\frac{\omega}{p^2 + \omega^2}\right]\left[\frac{1}{p + R/L}\right]$$

$$= \left[\frac{E}{L}\right]\left[\frac{\omega}{\omega^2 + R^2/L^2}\right]\left[\frac{1}{p + R/L} - \frac{p}{p^2 + \omega^2} + \frac{R/L}{p^2 + \omega^2}\right]$$

$$= \left[\frac{E\omega}{L\,(\omega^2 + R^2/L^2)}\right]\left[\frac{1}{p + R/L} - \frac{p}{p^2 + \omega^2} + \frac{R\,\omega}{L\omega\,(p^2 + \omega^2)}\right]$$



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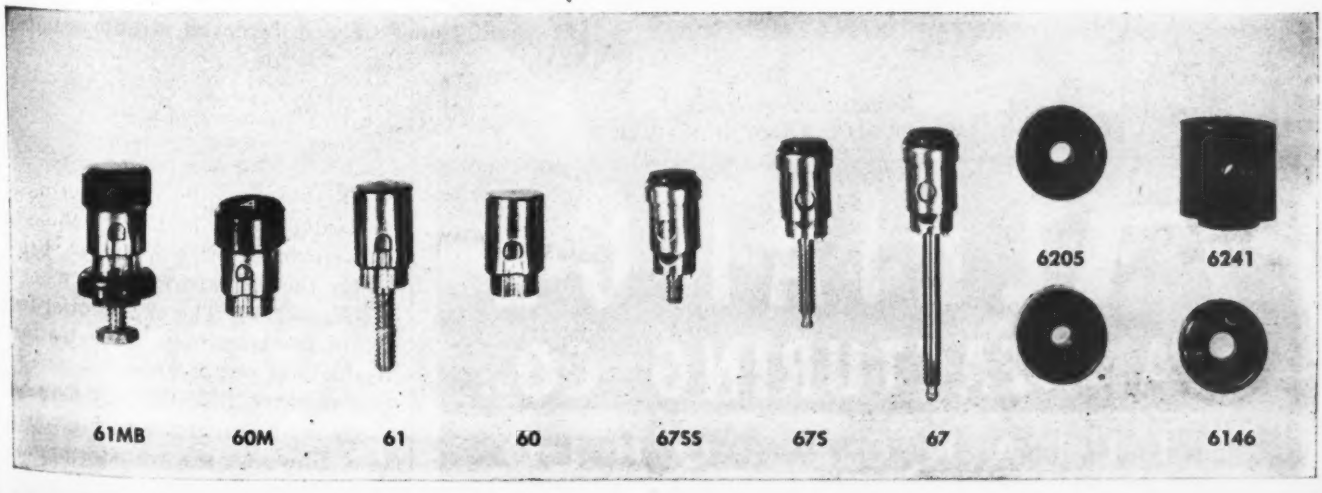

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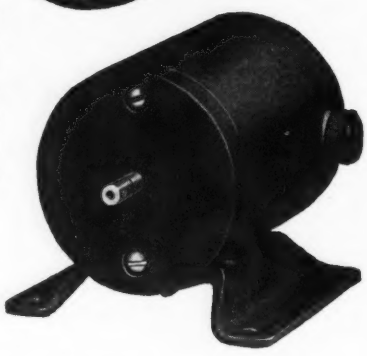

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Replacing the transformations by their time functions

$$i = \left[\frac{E\omega}{L(\omega^2 + R^2/L^2)}\right] \times [\epsilon^{-Rt/L} - \cos\omega t + (R/\omega L)\sin\omega t]$$

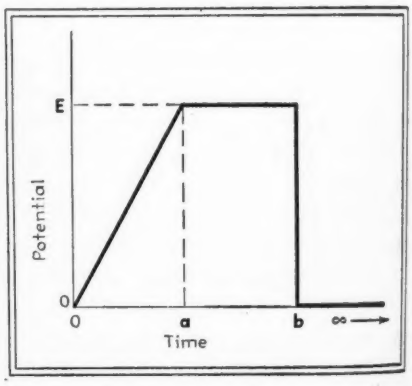
Circuit Response to Complex Voltage

If the voltage applied to the same circuit were a discontinuous function such that from $t = 0$ to $t = a$ it were Et/a, and from $t = a$ to $t = b$ it were E, and from $t = b$ to $t = \infty$ it were zero, what would be the current vs time? In this type of problem, we must assume that the voltage is composed of three separate applied voltages, v_1, v_2, v_3.

$v_1 = Et/a$, and starts at $t = 0$
$v_2 = -E(t-a)/a$, and starts at $t = a$
$v_3 = -E$, and starts at $t = b$

All three voltages continue to ∞. The accompanying sketch shows the resultant applied voltage.

From $t = 0$ to $t = a$ the voltage is only v_1, which is Et/a. From $t = a$ to $t = b$ the voltage is $v_1 + v_2$, which is $[Et/a] - [E(t-a)/a] = E$. From



Applied voltage versus time for third illustrative example of Laplace transform

$t = b$ to $t = \infty$, the voltage is $v_1 + v_2 + v_3$ which is zero. The initial requirements are thus satisfied.

The differential circuit equation is

$$L(di/dt) + Ri = \underset{\text{from } t=0}{Et/a} - \underset{\text{from } t=a}{E(t-a)/a} - \underset{\text{from } t=b}{E}$$

As before, the transform of $L(di/dt) + Ri$ is $Lp\bar{i} + R\bar{i}$. The transform of Et/a is E/ap^2. From (14), the transform of $E(t-a)/a$ is $(E/ap^2)\epsilon^{-ap}$. The exponential factor of the transform indicates that it starts at $t = a$. This time correction appears automatically here because the original function involved $t-a$. However, the transform of E

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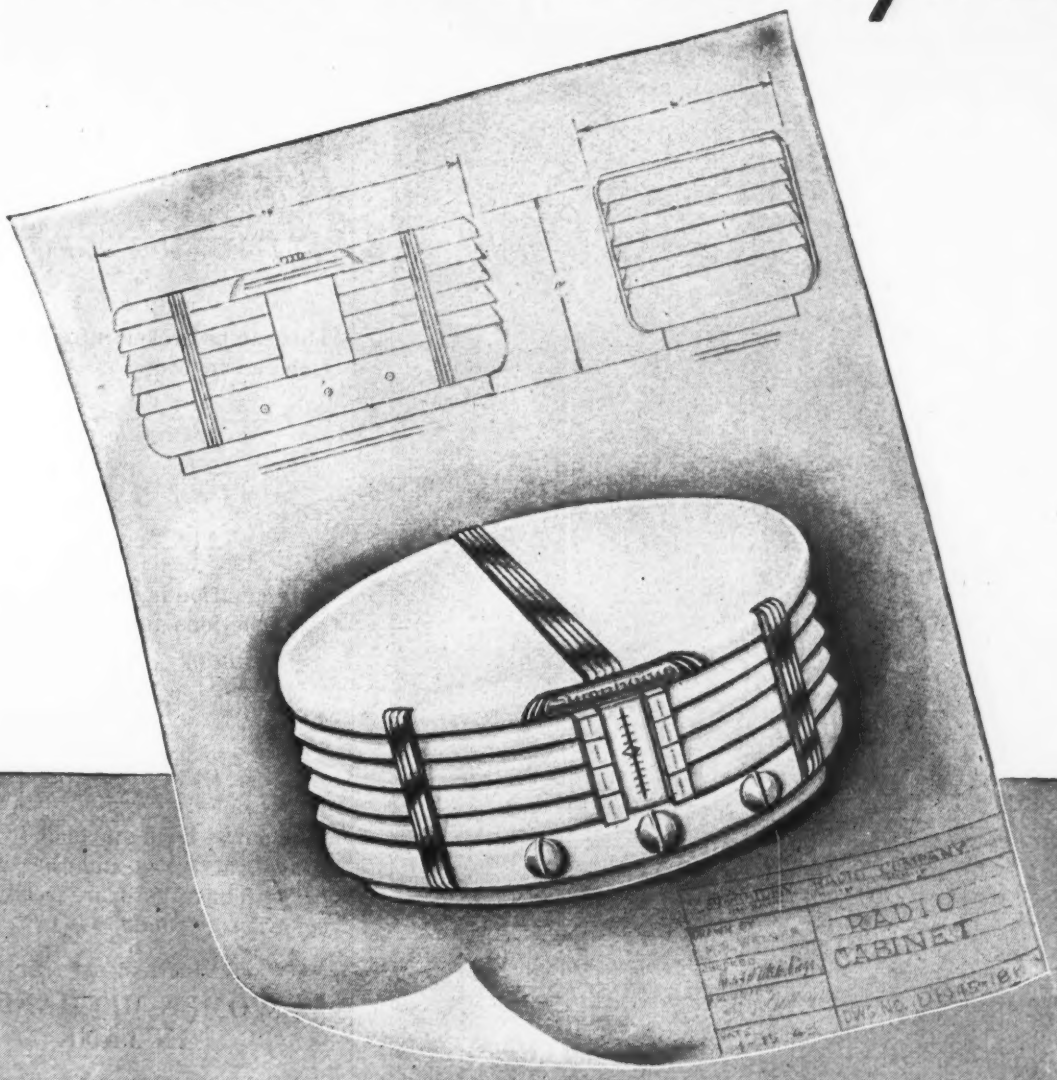

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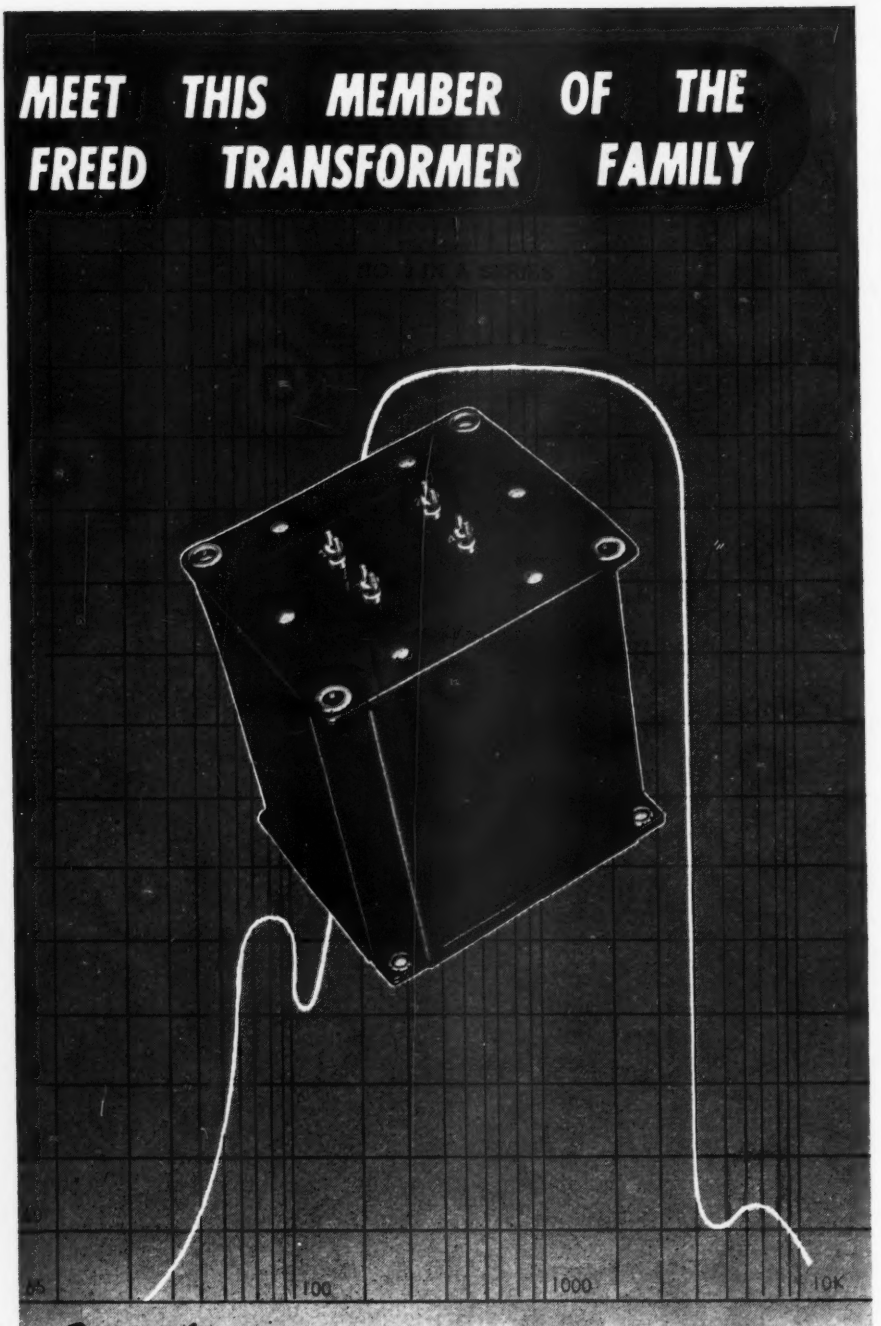

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which is normally E/p, must be multiplied by ϵ^{-bp} since it starts at $t = b$; thus the last term of the differential circuit equation transforms into $(E/p)\epsilon^{-bp}$. Here there was no $t-b$ to automatically provide the time correction, but it was understood that this term begins, not when $t = 0$, but when $t-b = 0$. The complete transform is

$$L p\bar{\imath} + R\bar{\imath} = (E/ap^2) - (Eap^2)\epsilon^{-ap} - (E/p)\epsilon^{-bp}$$

$$\bar{\imath} = \frac{E}{Lap^2\,(p + R/L)} - \frac{E\epsilon^{-ap}}{Lap^2\,(p + R/L)} - \frac{E\epsilon^{-bp}}{pL\,(p + R/L)}$$

This can be broken into partial fractions as follows

$$\bar{\imath} = \frac{EL}{aR^2}\left[\frac{1}{p + R/L} - \frac{1}{p} + \frac{R/L}{p^2}\right] - \frac{EL}{aR^2}\left[\frac{\epsilon^{-ap}}{p + R/L} - \frac{\epsilon^{-ap}}{p} + \frac{(R/L)\epsilon^{-ap}}{p^2}\right] - \frac{E}{R}\left[\frac{\epsilon^{-bp}}{p} - \frac{\epsilon^{-bp}}{p + R/L}\right]$$

This equation is solved by substituting functions for transforms.

$$i = \frac{EL}{aR^2}\left[\epsilon^{-Rt/L} - 1 + Rt/L\right] - \frac{EL}{aR^2}\left[\epsilon^{-(R/L)\,(t-a)} - 1 + (R/L)\,(t-a)\right] - \frac{E}{R}\left[1 - \epsilon^{-(R/L)\,(t-b)}\right]$$

The first term starts at $t = 0$, the second, at $t = a$, and the third, at $t = b$. Thus there are really three equations: from $t = 0$ to $t = a$ the

• • •

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59	67	109	127	
60	68	112	149	

PLP		PLQ		PLS	
56	65	56	65	56	64
59	67	59	67	59	65
60	74	60	74	60	74
61	76	61	76	61	76
62	77	62	77	62	77
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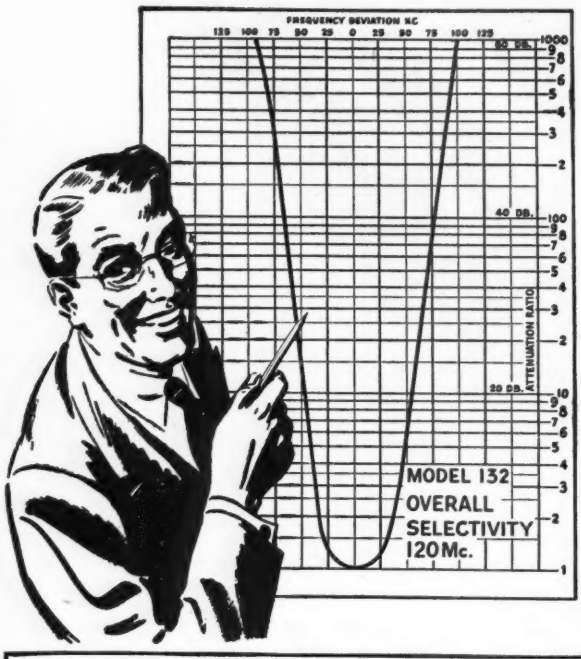

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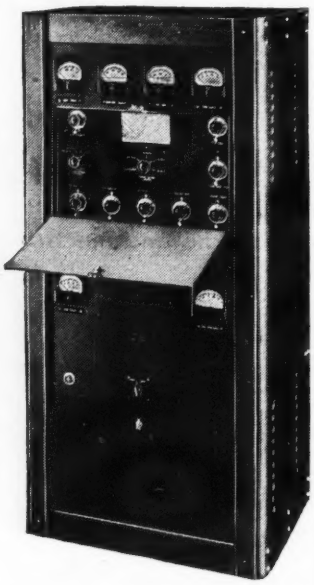

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value of i is given by the first term, from $t = a$ to $t = b$, by the first and second terms, and from $t = b$ to $t = \infty$ the whole equation gives the value of i. Note that at $t = a$ and $t = b$ there are two values of i, but that the function is continuous.

It is to be noted that in the second and third examples the Laplace transformation gives a quicker solution than the classical method. In the latter, it is necessary to guess at the answer and then check the accuracy of the guess. An experienced mathematician, that is, a good guesser, may attain a high degree of skill using the classical method but when he is stumped he will find the Laplace transformation a useful method to know.

• • •

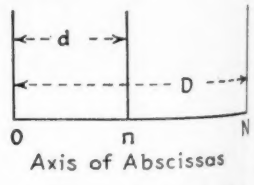
Parabolic Graph Paper for Square-Law Functions

By Albert Leen

It is often convenient to plot square-law functions such as $y = kx^2$ or $y = K\sqrt{x}$ as straight lines. One application is plotting the current indicated by a thermocouple galvanometer versus the deflection. Many such instruments have a scale calibrated in millimeters, with a known full-scale current of 110 milliamperes.

Parabolic graph paper can be ruled by scaling the axis of ordinates so that the length of an ordinate is proportional to its numeric value, that is—linearly, and scaling the axis of abscissas so that the length of an abscissa is proportional to the square of its numeric value. The axis of abscissas is scaled exactly according to the following relation:

$$d = D\,\frac{n^2}{N^2}$$



where d is the horizontal distance from the origin to the number n, n is the number associated with the ordinate at the distance d from the origin, D is the total length of the axis of abscissas, and N is the number represented by the distance D.

Another application is given in the accompanying power-current

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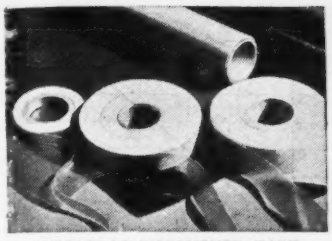

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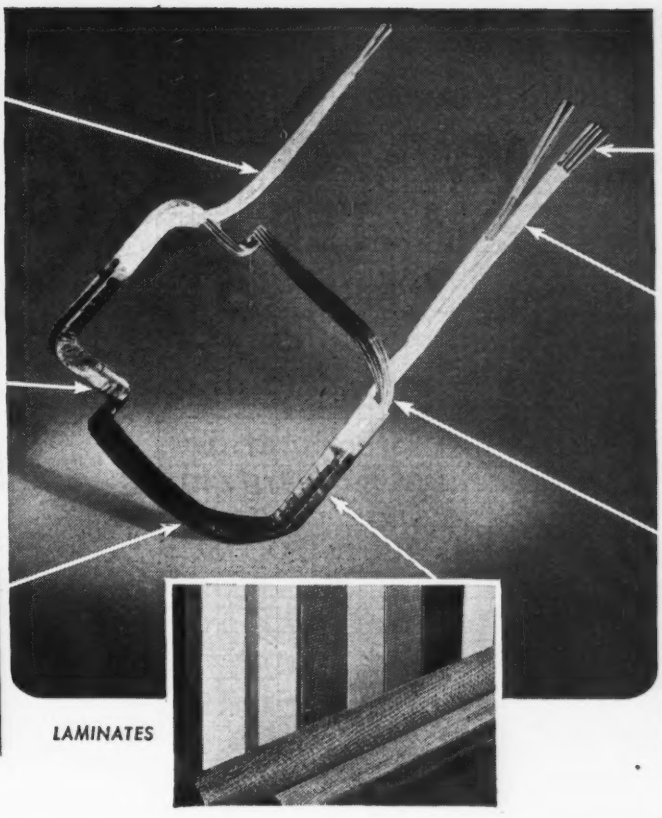

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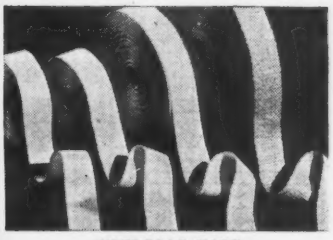
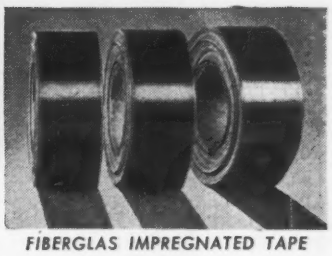


FIBERGLAS TAPE



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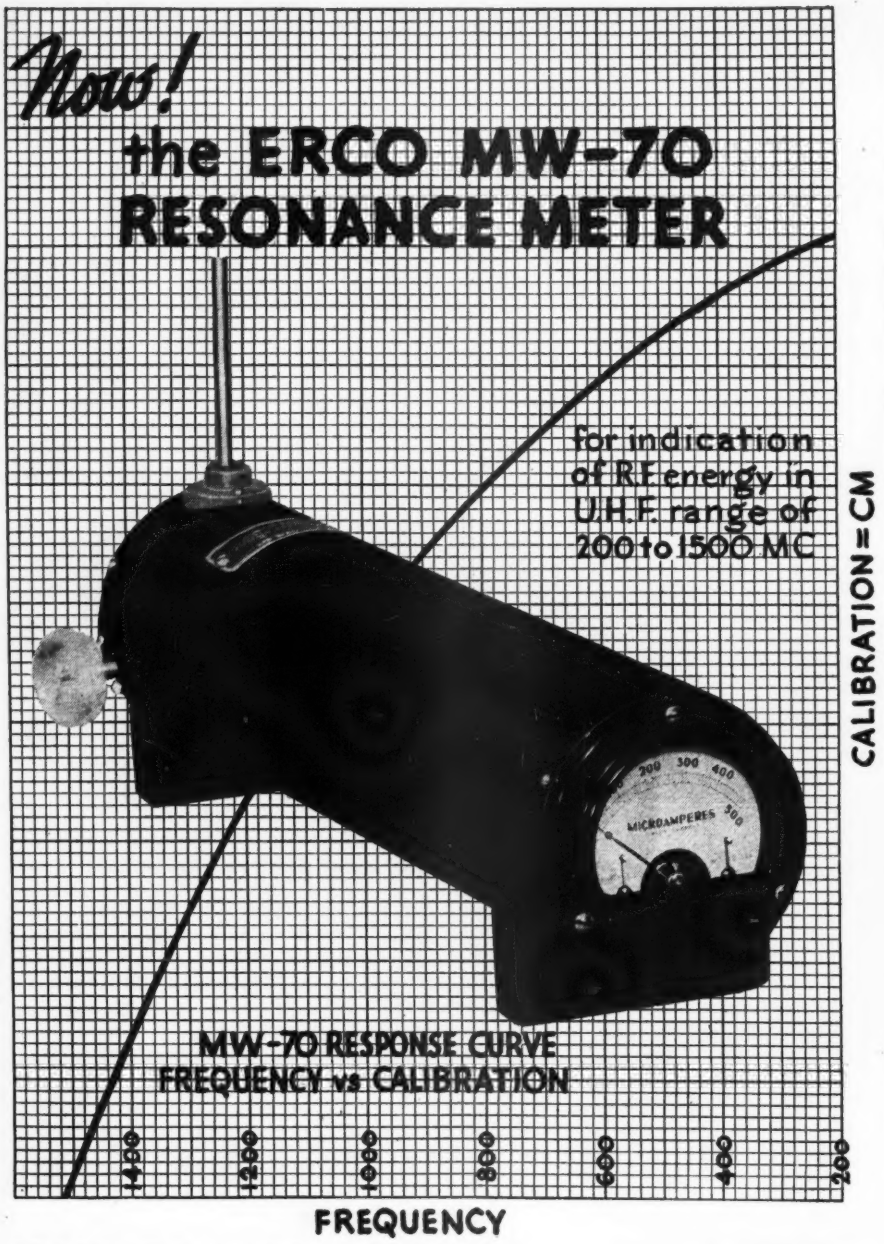

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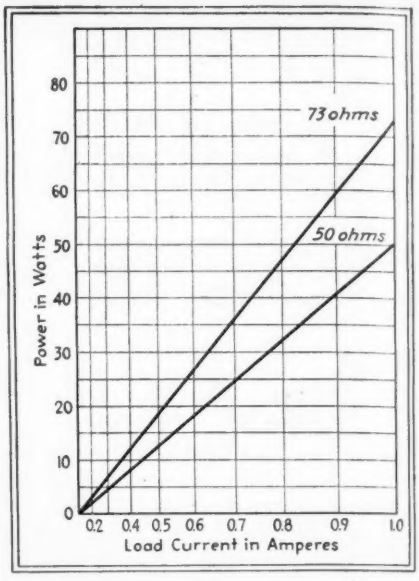

Power-current chart drawn on parabolic graph paper to provide straight lines

chart, where the power in a constant load resistance is drawn as a straight line, although the natural law is a parabola. Multiplying factors can be applied to the scales; if the current scale is multiplied by a, the power scale must be multiplied by a^2.

To plot power for a new value of resistance, calculate any convenient point and draw a straight line through the origin and that point. The abscissas can also be plotted as load voltage instead of load current.

• • •

TANK RADIO

With the British Eight Army, damaged radio equipment is sent from forward workshops to the REME Wireless Department for repairs by a skilled craftsman. In the photo above a repaired No. 19 set is handed up to Craftsman Jones of London for reinstallation in a Sherman tank

A MICA MINE
IN A LABORATORY

War shortages crop up in strange materials. Mica, for instance. Once seen principally in the windows of stoves, and in small boys' pockets, it is now used extensively as electrical insulation. In some war products, it is virtually indispensable: capacitors for radio, spark-plugs for airplane engines, insulators in electronic tubes.

With demand mounting, manufacturers were desperate. A four-man technical mission flew to London to help ration the world's supply between the United States and Great Britain. The shortage was serious.

The War Production Board, convinced that much mica was classified too low when judged by appearance alone, asked Bell Telephone Laboratories to develop a new method of electrical tests. The Laboratories were able to do this quickly and successfully because of their basic knowledge and experience in this field.

The new tests were made available to manufacturers in this country and abroad—the supply of usable mica was increased 60% — and a difficult situation relieved.

Skill to do this and other war jobs is at hand in Bell Laboratories because, year after year, the Laboratories have been at work for the Bell System.

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NEWS OF THE INDUSTRY

First FCC frequency allocations; battlefront radio; radar bombsight; conferences past; microwaves demonstrated; Conventions to Come; Washington News about Victory-First production and component availability; London Letter; Business News; Personnel

FCC Announces Allocations from 25 to 30,000 Mc

FEDERAL Communications Commission proposals for post-war allocations above 25 Mc were announced January 16th, based on the Allocations Hearings held last October. The findings, which are subject to review in hearings scheduled to start February 14th, are summarized in the accompanying table. A detailed analysis and interpretation will appear in the next issue.

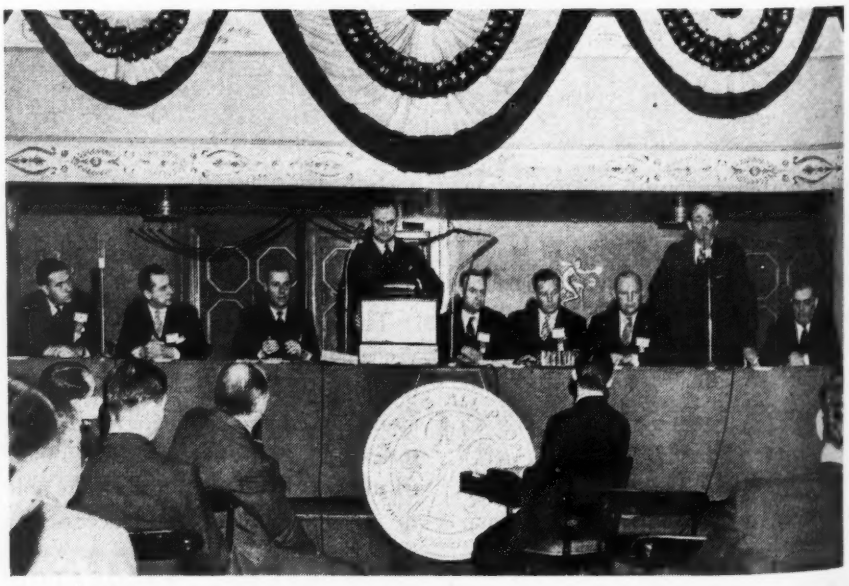
Type of Service	Number of Channels	Channel Width	Location in Spectrum (Mc)
Frequency Modulation (Commercial)	70	200 kc	88–102
Frequency Modulation (Educational)	20	200 kc	84–88
Television (Commercial)	12	6 Mc	44–50; 54–84; 180–216
Television (Experimental)	—	—	480–920
Television (Relay)	—	—	1225–1325
Aviation (Instrument Landing and Radio Ranges)	70	200 kc	108–118
Aviation (Traffic Control)	20	200 kc	118–122
Aviation (Air-Ground)	50	200 kc	122–132
Aviation (Experimental)	—	—	1550–1650
Aviation (Navigation Aids)	—	—	170–180; 420–460; 508–524; 960–1125; 1450–1550; 2300–2500; 2700–3900
Amateur	—	—	28–30; 50–54; 144–148; 220–225; 420–450; 1125–1225; 2500–2700; 5200–5750; 10,000–10,500; 21,000–22,000
Police	47	40 kc	30–44
		60 kc	152–156
Police (Exp. facsimile)	—	—	940–960
Fire Service	15	40 kc	30–40
	20	60 kc	156–162
Forestry	33	40 kc	30–40
	27	60 kc	156–162
Electric, Gas, Water, Steam (Utilities)	15	40 kc	25–44
	5	60 kc	156–162
Transit Utilities	10	40 kc	25–44
Special Emergency	4	40 kc	30–40
	6	60 kc	156–162
Provisional	27	40 kc	25–28
(Petroleum)	10	40 kc	30–40
	9	60 kc	156–162
Geophysics (Motion Picture) (Relay Press)	22	40 kc	25–28
	4	60 kc	156–162
Facsimile (Commercial)	Any FM Channel (simplex)	200 kc	84–102
Facsimile (Experimental)	—	—	470–480
*Railroad	33	60 kc	156–162
	20		44–50; 54–78; 192–216
*General Mobile (Taxicabs, etc.)	12	40 kc	30–40
	12	40 kc	42–44
	7	60 kc	156–162
*Citizens Radio-Communication (Walkie-talkie)	—	—	460–470
*Rural Telephone	—	—	44–50; 54–78; 192–216
*Rural telephone (Experimental)	—	—	1900–2300; 3900–4550; 5750–7050; 10,500–13,000; 16,000–18,000; 26,000–30,000
*Industrial, Medical (Scientific)	—	0.05%	13.66, 27.32, 40.98
Relay Systems	—	—	1225–1325; 1900–2300; 3900–4550; 5750–7050; 10,500–13,000 16,000–18,000 26,000–30,000
Fixed Public Services	—	—	44–50; 54–78; 192–216; 940–960; 1900–2300; 3900–4550; 5750–7050; 10,500–13,000; 16,000–18,000; 26,000–30,000
Coastal Ship	33	40 kc	30–44
	7	60 kc	156–162
Relay Broadcast	22	40 kc	25–28
	4	60 kc	156–162
Studio-Transmitter	—	—	940–960
			192–216
Development Broadcast	—	—	920–960

* New class of service.

Lunar Television Described at TBA Conference

REMOTE TELEVISION pickups from the moon are coming along one of these days, according to Vladimir K. Zworykin of RCA Laboratories, speaking at the banquet of the first annual conference of Television Broadcasters Association in New York recently.

Each recipient of a technical award (Zworykin, Bingley, DuMont, Espenscheid, Farnsworth, and Goldmark, as reported in ELEC-



Standing at right, O. B. Hanson, NBC, answers a question during the technical round-table session of Television Broadcasters Association's first annual conference in New York. Dr. Alfred N. Goldsmith, at the lectern, center, was the moderator. Seated participants are, l to r, F. J. Bingley, Philco; J. E. Keister, GE; Klaus Landsberg, Television Productions; A. H. Brolly, Balaban & Katz; Curtis W. Mason, KFI; A. B. DuMont; and C. B. Jolliffe, RCA

Precision Calibration Up to 2000 Mc's

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HARMONIC FREQUENCY GENERATOR

A big step forward in the FAST, EASY, ACCURATE calibration of RECEIVERS and WAVEMETERS. Suitable also for the calibration of OSCILLATORS and SIGNAL GENERATORS by means of a Beat Detector built into the instrument.

OUTPUT VOLTAGES in multiples of 10 or 40 megacycles are provided with CRYSTAL-CONTROLLED accuracy. Selects 10 or 40 megacycle series by means of a front panel switch. Identifies any ONE of these harmonics by means of a Frequency Identifier* which provides high attenuation of all voltages except that of frequency to be identified.

U H F

★ *Specify frequency of Identifier wanted.*

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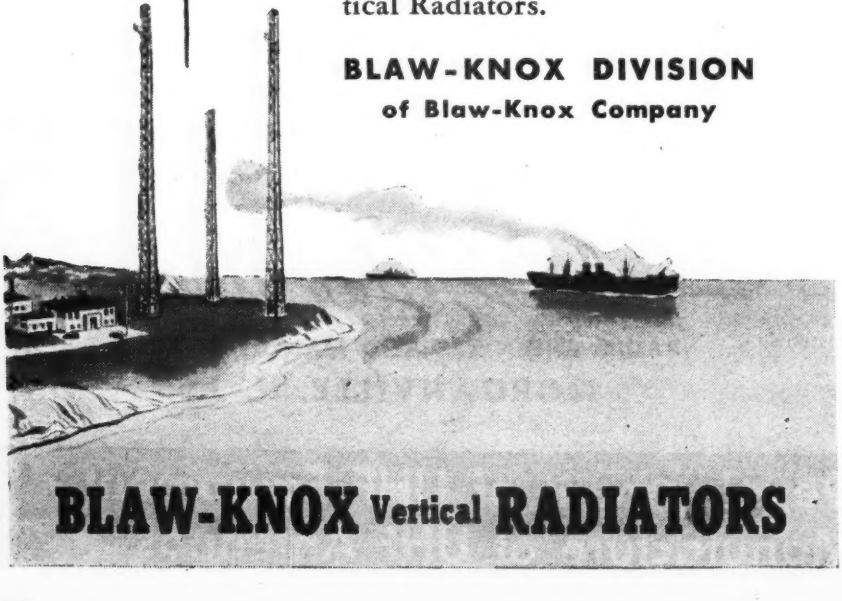
Specialists in The Development of UHF Equipment and in The Manufacture of UHF Antennas

BLAW-KNOX *puts through the Call!*

There are a hundred-and-one pieces of apparatus necessary to electronic operation but, finally the voice or picture goes out into space *via the antenna.*

Whether it's FM, Television or VHF you can be sure of getting the most out of your power and equipment by "Putting the Call Through" on Blaw-Knox Vertical Radiators.

BLAW-KNOX DIVISION
of Blaw-Knox Company



BLAW-KNOX Vertical RADIATORS

TRONICS for January) was asked to say a few words about the things he saw in the future of television. Tongue in cheek, Mr. Zworykin pointed out that with the trend as it is toward smaller and lighter equipment, it probably wouldn't be long before a teletransmitter could be pared down to the present size of a walkie-talkie—sort of a walkie-lookie.

The next step he visualized was the installation of one of these units in a rocket which could be sent to the moon, televising as it went. This prognostication to outprognosticate all prognosticators got a large hand from the group of more than a thousand who attended the dinner. Registration for all activities was in the neighborhood of 800.

Sixteen Medals Presented

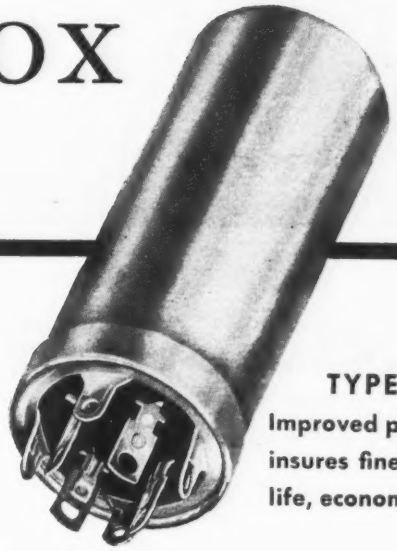
Additional awards for general contributions to television were made to: Brig. General David Sarnoff, Radio Corp. of America, for his initial vision of television as a social force and for the steadfastness of his leadership in the face of obstacles to television; W. R. G. Baker, General Electric Co., for his leadership in standardizing television through the National Television Systems Committee and supporting it through RTPB; David B. Smith, Philco Corp. for his work on NTSC and RTPB; and Dr. A. N. Goldsmith for his work on NTSC and RTPB and his vision in the relationship of motion picture and television.

Program awards were made to Sam Cuff, WABD; John Williams, WNBT; Robert Gibson, WRGB; Paul Knight, WPTZ; Worthington Miner, WCBW; and Klaus Landsberg, W6XYZ.

Some of the other activities of technical interest included discussions of network television by Harold S. Osborne, AT&T; Naval electronic training, by Commander Bill Eddy, Balaban & Katz; color, by Peter Goldmark, CBS; automatic radio relay systems, by W. S. Lemmon, International Business Machines Corp.; multiple-spectrum use, by D. B. Smith, Philco Corp.; tubes, by Merrill A. Trainer, RCA; and satellite transmitters, by J. E. Keister, GE. Proceedings are being published by the Association.

At the business meeting which

OLDEST IN NAME— NEWEST IN IDEAS MAGNAVOX



TYPE FP
Improved processing technique insures fine performance, long life, economy, speedy delivery.

"LOOK TO THE PAST for the future" in the case of Magnavox. This company, with radio's oldest name, is still pioneering . . . blazing new trails in design and advanced engineering. And its pioneering is made practical by 33 years of doing. *There is no substitute for experience!*

Specializing in FP (fabricated plate) Electrolytic Capacitors, with millions of them now in service, Magnavox is able to effect a full standardization program with all the advantages to you that this provides. Our technical department is available for consultation regarding capacitors for special applications.

After Victory, we shall again serve the radio industry in the traditional Magnavox manner, with the added advantages of our new developments and the superb equipment of our new modern six-acre plant.

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Magnavox
has served the radio industry 33 years

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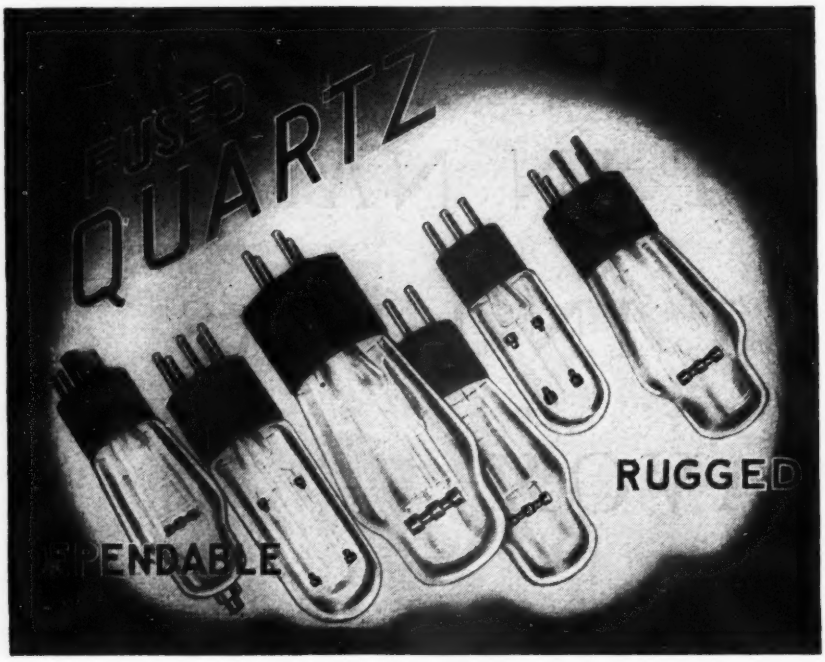

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are a "main factor" of the high power electronic tube. Quartz is the best electrical insulator known to science. Many other qualities make it ideal for the job. . . . Not subject to thermal shock. Non hygroscopic. High surface resistance. Shaped to specification.

ULTRA VIOLET LAMPS (quartz mercury arcs)

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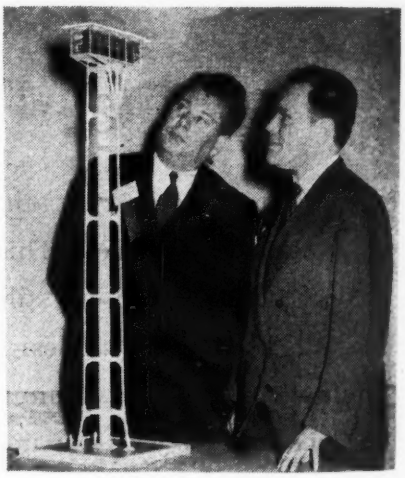
ended the conference, J. R. Poppele, chief engineer of Bamberger Broadcasting Service, was elected president to succeed Allen B. DuMont and O. B. Hanson of NBC was made assistant secretary-treasurer. Eight new members were accepted, bringing the full roster to 37.

Included in the conference itself was at least one technical achievement. Twenty-eight video receivers were installed in the conference hall under the supervision of F. J. Bingley, Philco Corp., and arranged to work from common antennas through a special amplifier having a separate output tube for each receiver. Interference between channels was eliminated and tuning was entirely satisfactory. This development is heralded as a solution to apartment-house and other large-building installations.



Paul L. Chamberlain, manager of sales for GE's transmitter division and Walter S. Lemmon, general manager of the Radiotype Division, International Business Machines Corp., examine a model of the automatic relay tower the two companies propose to use in networking radiotype, facsimile, fm, and television. This is a six-channel unit

IRE Award Citations

THE AWARDS COMMITTEE of the Institute of Radio Engineers has reported the following individuals for various honors as indicated:

H. H. Beverage, Radio Corp. of America, for the Medal of Honor in recognition of radio research toward efficiency in communications and devotion to affairs of IRE.

W. W. Hansen, Sperry Gyroscope Co., the Morris Liebmann Memorial Prize for application of electro-

for the 5th time

GENERAL RADIO was granted the coveted Army-Navy "E" Production Award for the fifth time in December of last year. G-R is one of very few in the electronic industry to receive this honor five times.

The production of precision electrical test equipment is a highly specialized business, demanding maintenance of close tolerances in all inspection, manufacturing and calibrating operations. Constant and close supervision by highly trained personnel is required to produce equipment of the precision and reliability of G-R instruments.

In order to meet the greatly increased production called for by the war, G-R has expanded to its limit, both in space and in personnel. We have subcontracted machining operations to several local firms; we have transferred our entire VARIAC production to leased space in another building; we have obtained considerable space in another building where we have contracted for a large number of war-time workers under our own foremen; we have let out the complete manufacture of several instruments to other manufacturers; we have turned over the design, drawings and models of several critical instruments to other manufacturers for their exclusive use.

G-R is proud that it has been able to meet the urgent production requirements of the war effort. It is equally grateful that the substantial contributions from its Development and Engineering Departments, through many thousands of hours of consulting engineering on secret war projects, have directly assisted in the solution of technical problems of the greatest urgency.

GENERAL RADIO COMPANY Cambridge 39, Massachusetts
NEW YORK CHICAGO LOS ANGELES

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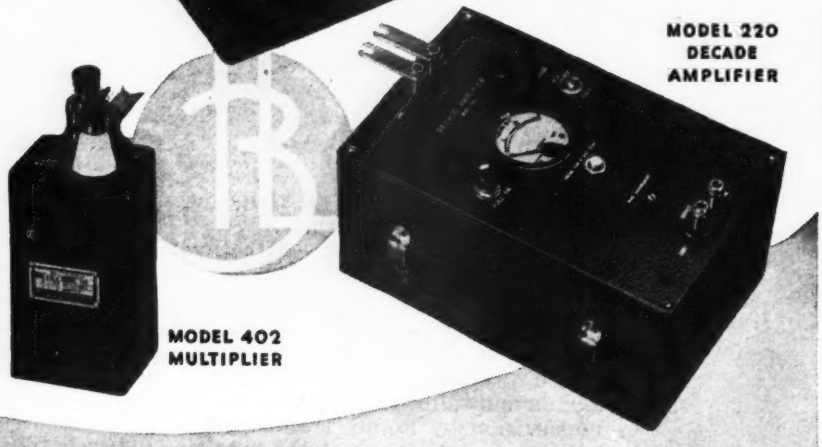
MODEL 300
ELECTRONIC VOLTMETER



MODEL 220
DECADE
AMPLIFIER

MODEL 402
MULTIPLIER

This enormous range of voltages—five hundred million to one—is accurately covered by our Model 300 Electronic Voltmeter and some of the accessories shown above. Frequency range 10 to 150,000 cycles. Accuracy 2% over most of the range. AC operation. Five decade ranges with logarithmic scale make readings especially easy. Uniform decibel scale also provided. May also be used as a highly stable amplifier, 70 DB gain, flat to 150,000 cycles.

BALLANTINE LABORATORIES, INC.

BOONTON, NEW JERSEY, U. S. A.

magnetic theory to radiation, antennas, resonators, and electron bunching; and for development of practical microwave equipment and techniques.

H. H. Buttner, International Telephone & Radio Mfg. Co., fellowship in recognition of radio communication activities in the international field.

O. H. Caldwell, Caldwell-Clements Inc., fellowship for contribution in broadening the horizon of the engineer by efforts to increase the use of electronic principles in industry.

W. H. Doherty, Bell Telephone Laboratories, fellowship for contribution to the development of radio transmitting equipment.

A. W. Hull, General Electric Co., fellowship in recognition of contribution to the design of radio and industrial electron tubes.

A. L. Loomis, Loomis Institute for Scientific Research, fellowship for work in the application of electronic techniques to medical research and for contribution to microwave development.

A. V. Loughren, Hazeltine Service Corp., fellowship for contribution to broadcast and television engineering.

F. X. Rettenmeyer, Radio Corp. of America, fellowship in recognition of development of broadcast,

• • •

CANADIAN YL SCHOOL

Members of the RCAF Women's Division take up the intricacies of an English model aircraft transmitter and receiver as part of their training as radio-telephone operators

more efficient ...in miniature

Compared to the light, accurate, hard hitting guns of today, the blunderbuss of our forefathers was a clumsy, uncertain weapon. Engineering has gone a long way in the development of more efficient firearms. And the modern miniature electronic tube is just as revolutionary. A little glass enclosed TUNG-SOL Tube, not much bigger than an acorn, will do the work of a large old type tube and generally do it better.

To set builders, compactness of tubes is so important that TUNG-SOL is making new type tubes and redesigning many of the old types in miniature. Old types are continued in production, however, for replacement in existing equipment.

Manufacturers of radio sets and other electronic devices are invited to work with TUNG-SOL engineers in the development of more compact and more efficient electronic equipment through the use of miniature tubes. Of course, consultation work of this nature is strictly confidential.

TUNG-SOL

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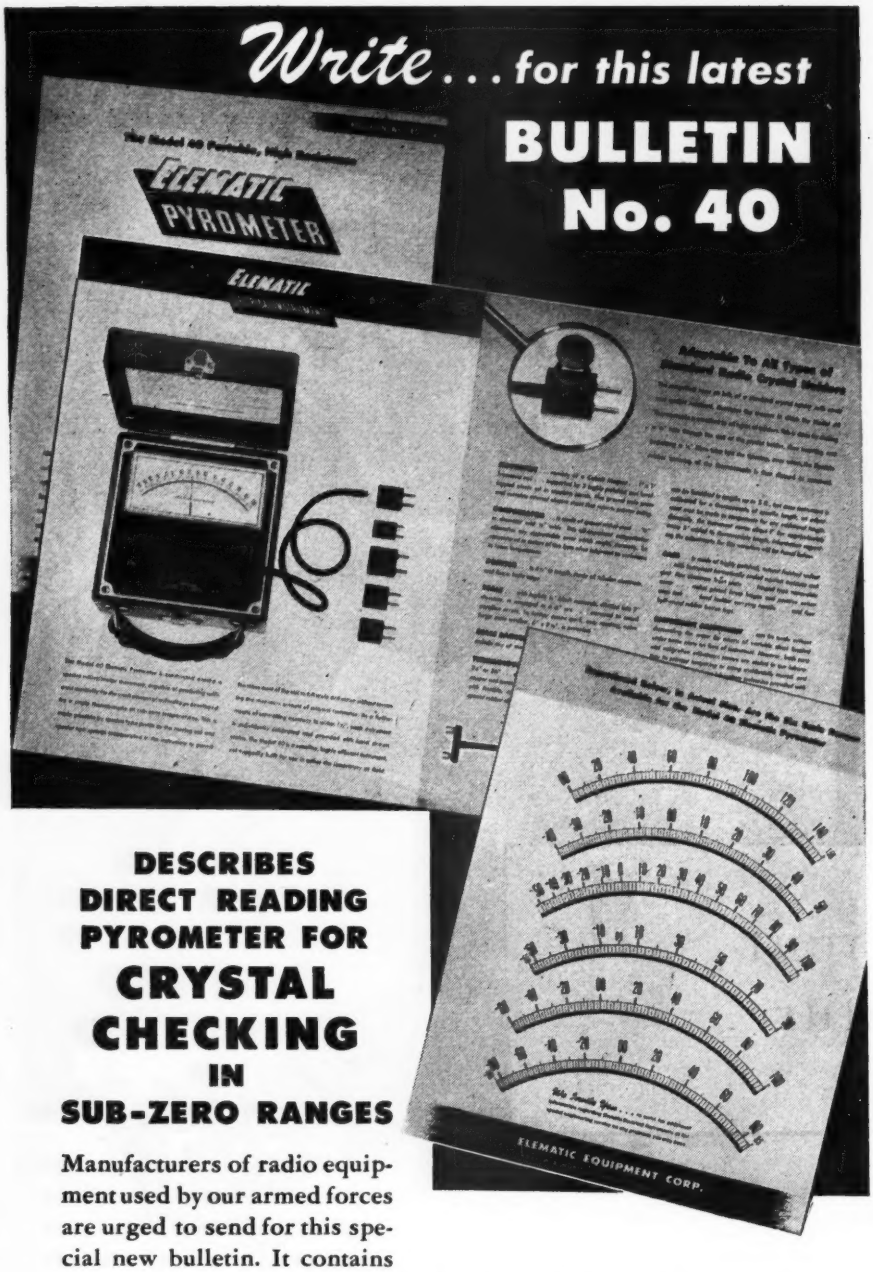
ELECTRONIC TUBES

TUNG-SOL LAMP WORKS INC., NEWARK 4, NEW JERSEY

Also Manufacturers of Miniature-Incandescent Lamps, All-Glass Sealed Beam Headlight Lamps and Current Intermittors



DESCRIBES DIRECT READING PYROMETER FOR CRYSTAL CHECKING IN SUB-ZERO RANGES

Manufacturers of radio equipment used by our armed forces are urged to send for this special new bulletin. It contains not only photographs and some of the more important features of the Model 40, but complete technical data regarding its construction and operation for checking temperature changes in radio crystals. Already this instrument has proven indispensable to numerous manufacturers—and has been subjected to exhaustive tests by them as well as Elematic engineers. It is accurate to within 1½° . . . has features and advantages not to be found in other pyrometers . . . is adaptable to all types crystal holders . . . and available in six scale ranges. Sold with an unconditional guarantee, the instrument is vital in any laboratory where closer control of production is essential.

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ELECTRICAL INSTRUMENTS

automobile and aviation receivers.

S. A. Schelkunoff, Bell Telephone Laboratories, fellowship for mathematical contributions to electromagnetic theory.

R. L. Smith-Rose, Chicago Telephone Supply Co., fellowship for pioneer work in direction finding and radio propagation allied to leadership of an outstanding radio research group.

K. S. Van Dyke, Wesleyan University, fellowship for research on characteristics of piezo-electric crystals and their application to frequency control.

E. M. Webster, Federal Communications Commission, fellowship for contribution to maritime mobile radio services and promotion of safety at sea.

P. D. Zottu, Girdler Corp., fellowship for activities in high frequency dielectric heating.

Phones for Autos

RADIO-TELEPHONE SERVICE is planned for Philadelphia and Pittsburgh by Bell Telephone Co. of Pennsylvania. Available for trucks, buses, commercial vehicles, and private automobiles, the service will be charged on a fixed-fee basis similar to existing telephone billings.

Shortwave transmitters are planned for both cities and switchboards will be used to link vehicles with existing telephone service. It will be possible to call equipped vehicles within a radius of 15 miles from fixed telephone installations or to call fixed telephones from cars.

NAB Committee Appointments

RECENTLY ANNOUNCED by National Association of Broadcasters is the following list of individuals who have been selected to serve on the standing engineering committee for next year. Those listed have already indicated their acceptance of the appointments: Italo Martino, WDRC; Earle Godfrey, WBAB; T. C. Kenney, KDKA; Philip F. Hedrick, WSJS; J. B. Fuqua, WGAC; J. D. Bloom, WWL; Frank A. Dieringer, WFMJ; Stokes Gresham,

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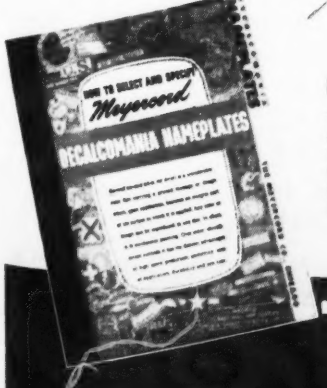
Oil Company Uses Meyercord Decals for New Coded Lubrication System

By the use of matching numerals applied with decalcomania, an ingenious "Coded Lubrication System", developed by a nationally known oil company, now provides positive identification between all lubrication points...grease guns...oil cans...storage containers. Meyercord Decals are used throughout because of their brilliant, lasting visibility, ease of application, and resistance to oil, grease, vibration, acid, abrasion and temperature extremes. Meyercord Decals are the modern method for all nameplate identification. Investigate their flexible, low-cost use for your plant or product...for trademarks, operating instructions, wiring diagrams, factory charts, color codes, etc. They're washable and durable. Any size, design or colors can be produced for application to any commercial surface. Free designing and technical service is at your disposal. Write for literature. Please address all inquiries to Department 9-2.



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Tells how to select and apply the correct Decal to 16 different surfaces. Conveniently arranged in file folder form. Write for free Check Chart today.

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As featured in FORTUNE

POSTWAR **RADIO**

QUIET AS NIGHT

The radio the public will buy postwar must deliver Crystal Clear signal—as though heard across a still lake. The precision of Crystal Control is the foundation of radio which pours out of the speaker only those sounds that went into the microphone.

The cutting of Control Crystals, accurate to millionths of an inch, is an art Pan-El Labs have developed into a production operation, with consequent economy, and assurance of scheduled delivery.

Having produced Crystals to the most difficult wartime specifications, we can help you apply them to peacetime electronic uses.

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QUANTITY PRODUCERS OF STANDARD AND SPECIAL
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Jr., WISH; Oscar C. Hirsch, WKRO; Mark W. Bullock, KFAB; William G. Egerton, KTSA; Robert H. Owen, KOA; George Greaves, KPO; Lester H. Bowman, KNX; and J. D. Kolesar, KMO.

The Engineering Executive Committee consists of Porter Houston, WCBM, chairman; O. B. Hanson, NBC; Karl B. Hoffman, WGR; William B. Lodge, CBS; and J. B. Fuqua, WGAC.

Increasing Scope of Radio

IN THE FEDERAL Communications Commission's latest Master Frequency List, supplemented to September 1, 1944, there are 2022 numbers used as designations for frequency assignees. Uses are keyed to aircraft, agriculture, amateur, airport, aviation, broadcast, coastal harbor, coastal phone, coastal telegraph, direction finding, experimental, forestry, fixed, government, general communication, geophysical, guard band, international broadcast, intership phone, intership, mobile press, maritime calling, marine fire, motion picture, police, relay broadcast, relay press, ship harbor, ship telephone, state police, ship telegraph, special emergency, special services, and television broadcast—34 in all.

R-F Eyesight for Postwar?

ALLIED MILITARY LEADERS have officially disclosed the existence of the radar bombsight which makes it possible to find bombing objectives otherwise hidden by dust, clouds and smoke screens.

The first such unit was developed by British inventors during the Battle of Britain in 1940. Variously described as "Mickey" and the "gen box", the unit is capable of reproducing outlines of such targets as coastlines, cities and even individual buildings.

Radio for Army Truck Dispatching

A SIX-STATION RADIO net using SCR-399 radio sets in 2½-ton trucks is given credit for much of the efficiency of the express truck highway between the Normandy beachheads and our western front armies. This road, which was re-

THAT TRAIN WHISTLE STARTED ME THINKING

APPLICATIONS FOR D-C RECTIFIERS ARE LIMITLESS

Oftentimes the possibilities for a product are overlooked. Think for a few minutes about rectifiers. A small copper-oxide rectifier supplies the d-c power to make a toy train whistle—in steel mills, large rectifiers deliver output of 60,000 amperes to supply power for tin plating. From the smallest to the largest application for direct current, there are copper-oxide or selenium or Tungar rectifiers to fit the need.

ONLY G. E. OFFERS ALL THREE

Where other manufacturers offer one or two of these low cost, low voltage rectifiers, General Electric offers all three. Naturally, each type differs in characteristics, basic materials and construction. The most efficient rectifier for one application may be least efficient on the very next. It is in determining which type to use for each application that G.E. can help most—so look to G.E. for an impartial answer to all rectifier problems. For further information write to Section A255-119, Appliance and Merchandise Dept., General Electric Co., Bridgeport, Connecticut.

BUY WAR BONDS AND KEEP THEM

Hear the General Electric radio programs: "The G-E All Girl Orchestra" Sunday 10 P.M. EWT, NBC. "The World Today" news every weekday 6:45 P.M. EWT, CBS.

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Pioneers Yesterday
Pioneers Tomorrow
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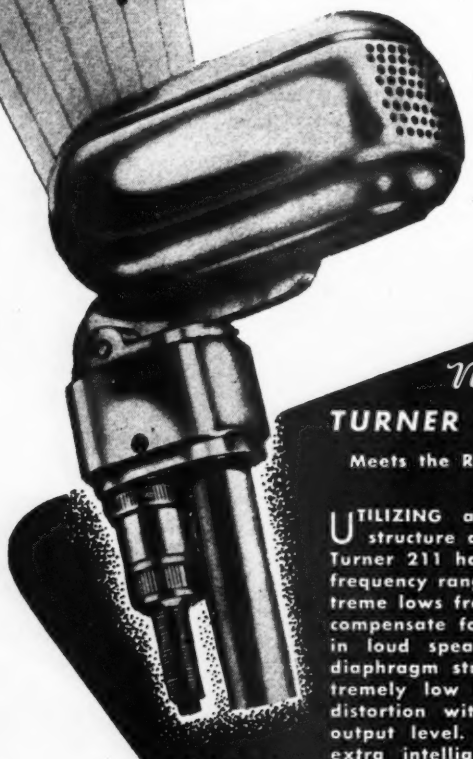
Microphones



(TURNER 211)

New
TURNER 211 Dynamic
Meets the Requirements of FM

UTILIZING a new type magnet structure and acoustic network, Turner 211 has extended the high frequency range and raised the extreme lows from 2 to 4 decibels to compensate for overall deficiencies in loud speaker systems. Unique diaphragm structure results in extremely low harmonic and phase distortion without sacrificing high output level. A sensitive unit for extra intelligible sound transmission, Turner 211 has wide application in military and industrial areas, as well as for P.A. systems and broadcast studios, including FM. Write for specifications.

9X-D

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Free
Write for Free Turner Microphone Catalog giving complete information on all Turner Microphones.

Crystals licensed under patents of the Brush Development Co.

The TURNER Company
CEDAR RAPIDS, IOWA

ferred to as the Red Ball Express, existed only 81 days but carried more than half a million tons of supplies a distance of 700 miles before being discontinued in favor of the repaired French railways.

When truck convoys were formed up at the western end of the highway, a message was forwarded to all stations along the route, describing the contents and destination and giving full instructions as to its handling. Peak traffic handled in a single day was 93 messages averaging approximately 60 words per message.

Scavenged Fifty-Watter

RADIO KWAJALEIN is located on Kwajalein atoll in the Marshall Islands. It occupies a space 12 ft. by 5 ft. and puts out 50 watts of power from salvaged Army, Navy, and Marine Corps equipment, combined with a scattering of captured Japanese and personally donated items.

Conceived by Major Leland W. Smith, of Winston-Salem, N. C., previously an active ham, the equipment is manned by Marine Corps personnel. Because of the lack of tools, almost two months time was devoted to assembling such items

Marine Technical Sergeant Charles T. Haas, Tucumcari, New Mexico, cues in the news commentator at Radio Kwajalein, Kwajalein Atoll, Marshall Islands

as an aluminum panel from a damaged Liberator, power plant and turntables which had been discarded as unserviceable by the Navy; quartz frequency-control crystals ground on the spot; and coils and transformers made up by the builders.

The daily schedule includes transmission from 6 to 7:30 a.m., from noon to 2 p.m., and from 5 to 9 p.m. Most of the construction work was done by Marine Technical Sergeant Charles T. Haas of Tucumcari, New

"The following is electrically transcribed..."

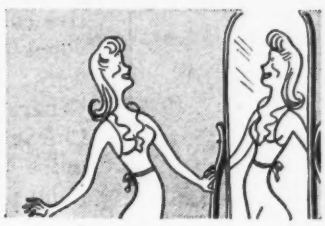
on PRESTO discs!

Pepsi-Cola's bouncy little ditty seems likely to become an American folksong. It has been played on the air more than a million times since 1939. You've heard it in swing-time and in "classical" versions for the intelligentsia. It has made Pepsi-Cola a buy-word in homes throughout the nation.

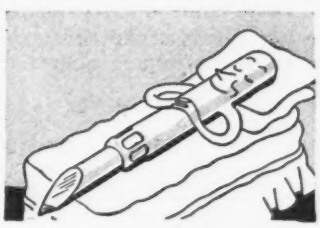
Pepsi-Cola "spots" are cut on PRESTO discs. *Most important transcriptions are.* For recording engineers know that PRESTO discs give finer results with less margin for error—*actually perform better than most of the recording equipment on which they are used.* That's why you'll find, in most large broadcasting stations, recording studios and research laboratories, the standard recording disc is a PRESTO.

WHY BROADCASTING STUDIOS USE MORE PRESTO DISCS THAN ANY OTHER BRAND

Less Surface Noise



No Distortion



Easier on Cutting Needle

No Fussy Needle Adjustments

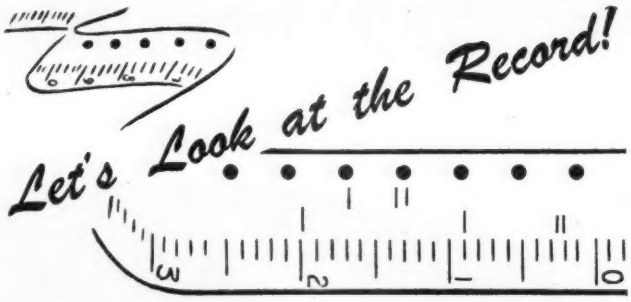
WORLD'S LARGEST MANUFACTURER OF INSTANTANEOUS SOUND RECORDING EQUIPMENT AND DISCS

PRESTO

RECORDING CORPORATION

242 West 55th Street, New York 19, N. Y.

Walter P. Downs Ltd., in Canada



AUTHENTIC - UNASSAILABLE IN LABOR RELATIONS

Time study records permanently printed on tape—easily read by anyone. Values accurate to .0025 minutes.

the New

MARSTO-CHRON

MODERNIZES TIME STUDIES

FAST ACCURATE CONVENIENT

No watch to read—no notes to make. Records are made simply by tapping the keys, while observer devotes full attention to operations.

- ✔ Saves time because fewer observations are needed.
- ✔ Easy to read—Easy to keep for later reference.
- ✔ Every motion recorded at instant of occurrence —no need to combine elements.
- ✔ Increases confidence between management and labor.

Lower costs **now** for successful postwar competition. Send today for full information on how Marsto-Chron can help.

BAY PRODUCTS CORP.
171 CAMDEN STREET
BOSTON 18, MASS.

Mexico. Modern circuits were used throughout and modified only where absolutely necessary because of material shortages.

Parts and Equipment Conference

DURING OCTOBER a registration of nearly 1,500 attended the Electronic Parts and Equipment Industry Conference at the Hotel Stevens in Chicago. Sponsored by the Electronic Parts and Equipment Manufacturers; Eastern Div., Sales Managers Club; RMA; and National Electronic Distributors Association, the meeting featured 150 manufacturers who maintained conference booths as well as a large participation by distributors and manufacturers' representatives.

Signal Corps Afloat

AS THE PHILIPPINE invasion materialized, facilities for broadcast and press coverage were provided by Army Communications Service of the Signal Corps. A special Signal Corps radio ship was utilized as part of the fleet which landed the invasion forces. Involved was the largest network in history. It provided at least two alternate circuits for transmission of broadcast and press material including radiophotos.

Additional RMA Members

AT A RECENT MEETING of the Radio Manufacturers Association executive committee, nine concerns were voted into active membership. These were: Ensign Coil Co., Chicago; General Television & Radio Corp., Chicago; Lear Inc., Chicago; Maguire Industries Inc., Greenwich, Conn.; Permoflux Corp., Chicago; Radio and Television Inc., New York; Rek-O-Kut Co., New York; Screenmakers, New York, and Stupakoff Ceramic & Mfg. Co., Latrobe, Pa.

Microwave Demonstration

FOR THE FIRST TIME, NDRC has authorized discussion and demonstration of a complete microwave system for communication purposes. It was presented at the 597th meeting of the New York Electrical Society recently by Dr. George B.

CAPACITOR SELECTION *Simplified*

SPRAGUE CAPACITOR TYPES

Dry Electrolytics Paper—Mica
Power Factor Correction
High Voltage Networks
*Vitamin Q Capacitors
Radio Noise Suppression Filters, etc., etc.

SPRAGUE RESISTOR TYPES

*Koolohm Wire-Wound Power
Hermetically-sealed Wire Wounds
Bobbin Types
Voltage Divider Sections
Precision Meter Multipliers, etc.

*T. Ms. Reg. U. S. Pat. Off.

Probably no type of Electrical-Electronic component affords a greater variety of selection for a given application than capacitors. Probably no component is more susceptible to design changes to accommodate given conditions. Moreover, nowhere has engineering been moving faster in developing new types, improving old types and, in general, changing past conceptions of Capacitor usage.

That's why proper Capacitor selection is no casual matter—and this, in turn, is why we make the following recommendation to Capacitor users:

Write today for a supply of Sprague Capacitor Sample Request Forms. Then, as Capacitor applications arise, send full data to Sprague engineers on these forms. Let Sprague consider all factors involved—both in the light of long, specialized experience, and of the latest Capacitor developments or adaptations which Sprague engineering may have to offer.

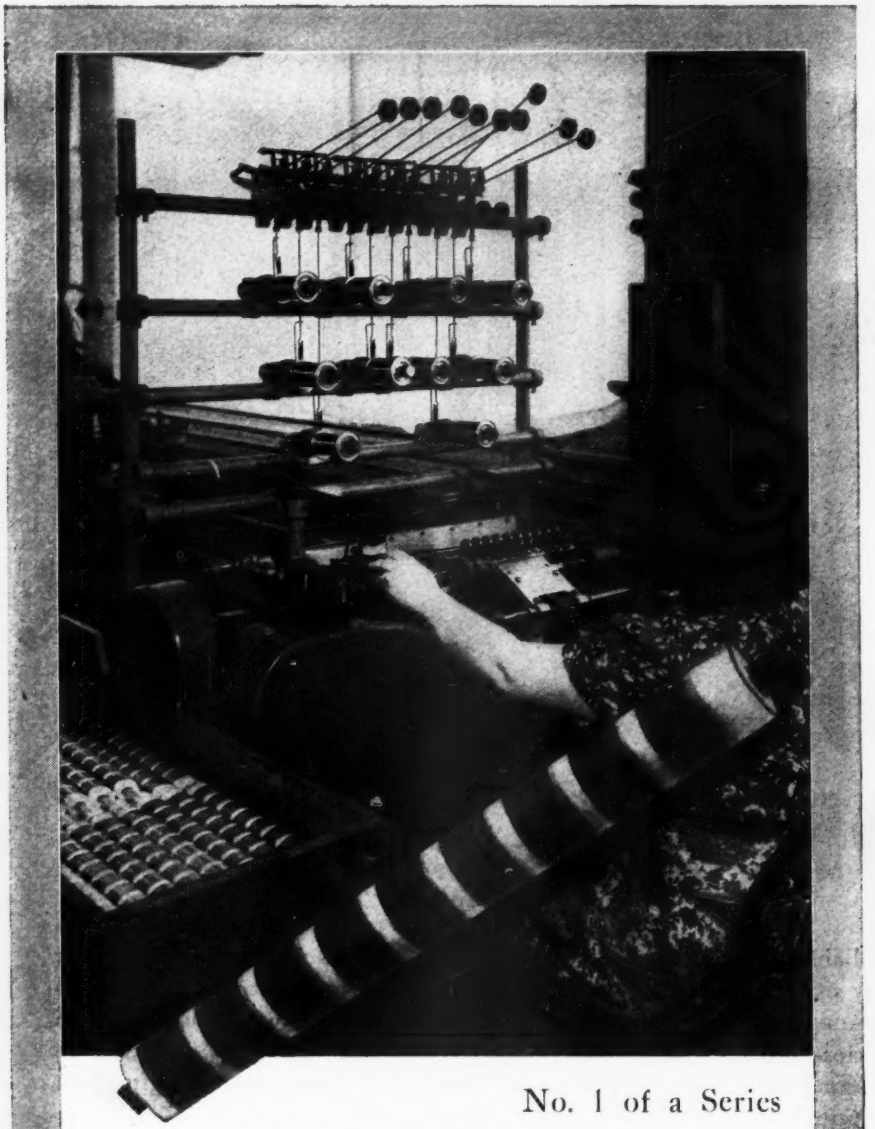
It takes no longer to buy Capacitors on this basis. Such service makes them cost no more—and it frequently means important savings, increased efficiency on your production line, and greater dependability for your product.

SPRAGUE ELECTRIC COMPANY, North Adams, Mass.
(Formerly Sprague Specialties Co.)

ARMY E NAVY

SPRAGUE

CAPACITORS — *KOOLOHM RESISTORS



No. 1 of a Series

COTO CLOSE-UPS

Back of each COTO coil winding lies engineering skill . . . expert craftsmanship and "know how" . . . and much highly specialized equipment. All play their parts in assuring correct coil function and production costs in line with your requirements.

Modern Coil Winding in Multiple Groups

Nine coils are shown being wound simultaneously with .0007" thick cellulose acetate film interleaved between layers of wire.

Machines are automatic and versatile . . . capable of handling a range of wire from #18 to #42 and acetate film or paper insulation from .0007" to .005" thick . . . at high speed.

These modern facilities are available now for war components and essential rated requirements.

COTO-COIL CO., INC.
65 PAVILION AVE., PROVIDENCE 5, R. I.
COIL SPECIALISTS SINCE 1917

Hoadley who is in charge of the instructional microwave laboratory at the Polytechnic Institute of Brooklyn.

Pointing out that the impetus of the war has been such as to make networks of microwave booster stations actually practical, Dr. Hoadley demonstrated the use of plain sections of galvanized iron drainpipe as wave guides and showed by analogy the reflection of microwave beams from topographic objects.

The lecture included a discussion of protective equipment for ships and planes to utilize radar principles in movements through fog. He also displayed a horn-type radiator which is analogous to the horn on a loudspeaker, a parabolic reflector analogous to a searchlight, and a Klystron oscillator.

New IRE Section

Members of the newly approved Cedar Rapids Chapter of IRE discuss a presentation of Centralab products. Left to right are: R. V. Guettler, G. Milton Ehlers, and W. S. Parsons of Centralab, standing, and T. A. Hunter, Collins Radio Corp., temporary chairman of the section.

THIRTY COUNTIES in Iowa and two in Illinois are included in the scope of a new institute of Radio Engineers Chapter with headquarters at Cedar Rapids, Iowa. Membership is expected to run to about 100, 64 having been in attendance at the organizational meeting held recently. Temporary chairman is T. A. Hunter of Collins Radio Corp.

Post-War Radio Services

NOW IS THE TIME to start assembling the additional "know how" radio service men will need to keep pace with post-war developments in the radio field, thinks Leonard C.

They wanted
TOY-SIZE fastenings
able to withstand

¾" long, .037" dia.
140 threads to inch.

BIG-GUN CONCUSSION

. . . and for these threaded "pin size" parts they chose a strong, corrosion-resistant INCO Nickel Alloy

The enemy isn't the only one to feel the shattering shock of a naval broadside. When the big guns thunder, everything aboard ship takes a beating.

Yet delicate vital instruments must function without a hitch. Every part . . . even the tiniest . . . must be able to withstand the tremendous concussion.

One such part in an essential instrument, is a fastening the size of a common pin . . . approximately ¾" long, .037" in diameter with 140 threads to the inch.

The metal chosen for this fastening needs:

corrosion-resistance, a necessity for sea-going equipment.
strength and toughness, to hold up under shock.
machinability, to permit speedy, economical machine production.

All of these requirements add up to "R" Monel . . . the corrosion-resistant alloy for parts where extra machinability is important.

* * *

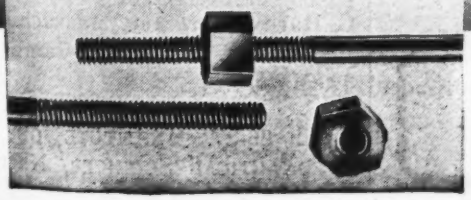
This use of "R" Monel is cited as an example of how INCO Nickel Alloys . . . such as "R" and "KR" Monel . . . often do the trick where a *unique combination* of properties is required.

If you have a problem involving metals . . . for equipment now in production, or planned for post-war . . . consult INCO Technical service. Write:

THE INTERNATIONAL NICKEL COMPANY, INC., 67 Wall Street, New York 5, N. Y.

Official U. S. Navy Photograph

140 THREADS TO THE INCH, *shown in this enlarged photograph, demonstrate the remarkable machinability of strong, corrosion-resistant "R" Monel. ("KR" Monel is suggested for applications where extra hardness is required.) The fastenings are machined from .037" diameter cold-drawn "R" Monel.*



INCO NICKEL ALLOYS

MONEL • "K" MONEL • "S" MONEL • "R" MONEL • "KR" MONEL • INCONEL • "Z" NICKEL • NICKEL
Sheet . . . Strip . . . Rod . . . Tubing . . . Wire . . . Castings

WIRED FOR SIGHT

Advanced Technique For Calibration of Reed Frequency Meters

Sighting a vibrating reed against the sound of a tuning fork may sound like double talk . . . but that is essentially the principle in the exacting process of J-B-T Frequency Meter calibration.

Tuning forks are the most dependable source of mono-chromatic vibration frequencies, so J-B-T engineers devised equipment, the *only* equipment of its kind, to translate the frequencies of temperature-controlled tuning forks into electronic impulses. These impulses are delivered to the stroboscopic and electronic calibration equipment at the assembly and inspection stations where they are used *visually* to prove the accuracy of every J-B-T Frequency Meter reed. And still not satisfied, J-B-T engineers check these master tuning forks daily against time signals from the Bureau of Standards.

The superiority of this equipment for frequency testing, exclusive with J-B-T, is recognized by authorities in the electrical industry and in the war effort. It is one of the reasons why J-B-T Meters can be guaranteed permanently accurate to ± 0.3% or better.

Send for illustrated bulletin VF-43, with supplements on 400 cycle meters, and the new compact 2½ inch meters.

For all 3½" instruments, black molded cases are now available to meet highest government standards and the mounting dimensions of ASA C 39.2—1944 and proposed JAN-I-6.

J-B-T

(Manufactured under Triplett Patents and/or Patents Pending)

2-JBT-3

J-B-T INSTRUMENTS, INC.

431 CHAPEL STREET • NEW HAVEN 8, CONNECTICUT

Truesdell of the Radio Division of the Bendix Aviation Corp., Baltimore, Md. Speaking at a meeting of Philadelphia radio servicemen, Truesdell predicted the appearance of new opportunities with fm and television.

Besides acquiring information, the service man should work on the assembly of modern facilities and equipment. A second phase can be the absorption of ex-servicemen whose advanced training in radio will make them particularly useful.

Electronics Exposition for Industry

WORKING EXHIBITS or demonstrations which utilize electronic principles are expected to be shown at the International Electronics Exposition, sponsored by the electronics section of NEMA, tentatively scheduled for the latter part of 1945.

Present plans are that the electronics section will exhibit statistical data showing use of electronic equipment in industry. A technical session or clinic will be included. Exhibitors are not to be restricted to the membership of the association.

CONVENTIONS TO COME

Feb. 20-21. RADIO MANUFACTURERS ASSOCIATION, Annual Mid-Winter Conference . . . Cancelled.

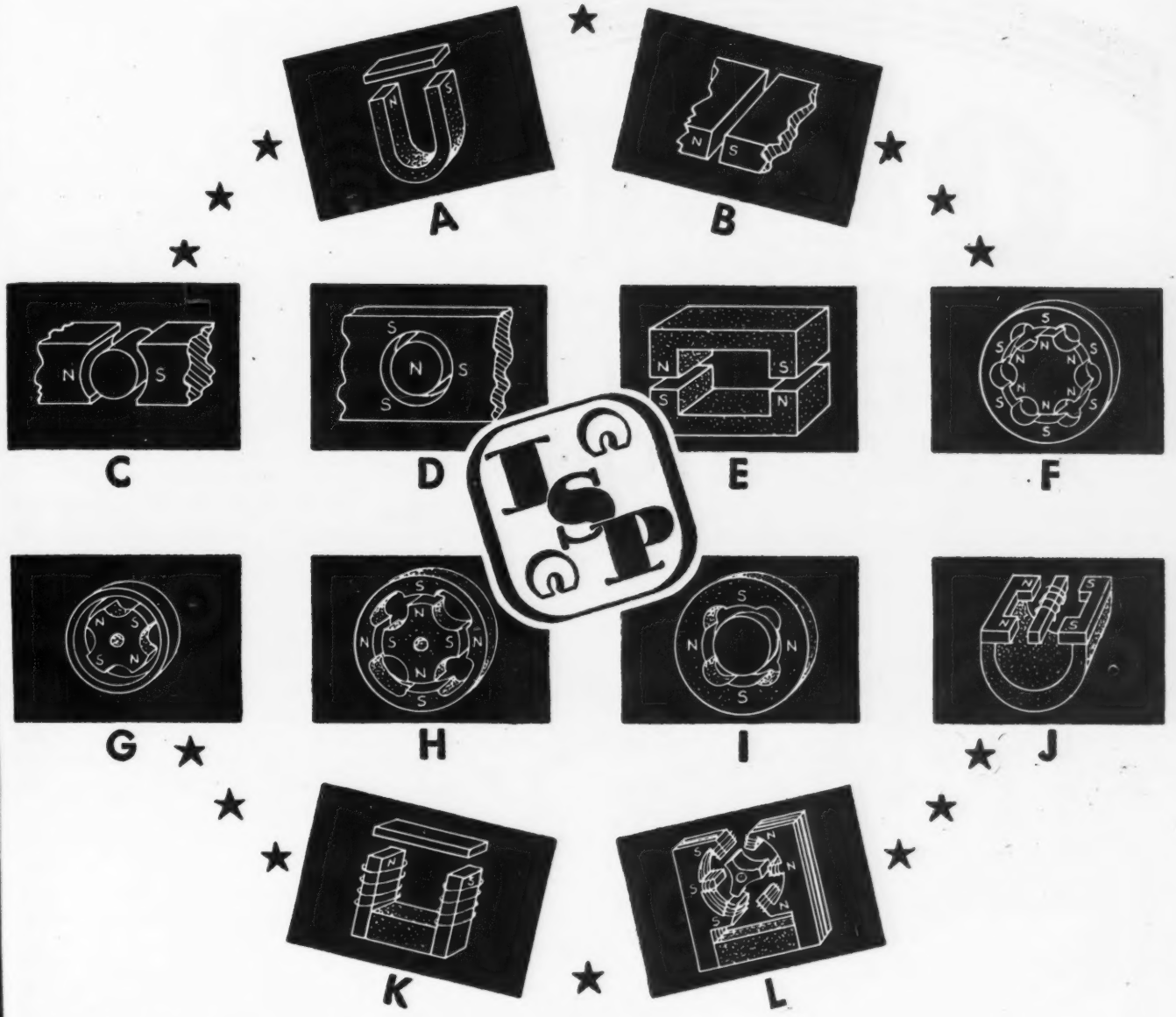
Feb. 26-March 2. AMERICAN SOCIETY FOR TESTING MATERIALS, Committee Week and Spring Meeting (28), William Penn Hotel, Pittsburgh, Pa. R. J. Painter, assistant to the secretary, 260 S. Broad St., Philadelphia 2, Pa.

April 12-14. ELECTROCHEMICAL SOCIETY, 87th General Meeting, Hotel Claridge, Atlantic City, N. J. Colin G. Fink, secretary, Columbia University, New York 27, N. Y.

April 12-14. OPTICAL SOCIETY OF AMERICA, Cleveland, Ohio. Arthur C. Hardy, secretary, Massachusetts Institute of Technology, Cambridge 39, Mass.

April 26-27. INSTITUTE OF THE AERONAUTICAL SCIENCES, National

PERMANENT MAGNETS MAY DO IT BETTER



Basic Types of Air Gaps

The space required for a magnetic field is known as an "air gap." Most of the fundamental types of air gaps are illustrated above—from the familiar form shown in "A," which is simply a permanent magnet with an armature adjacent to the poles of the magnet, to the inductor type alternator such as type "L."

The basic forms of permanent magnets and their associated air gaps are subject to infinite variations. They are used in a rapidly growing number of applications . . . potentially, there are unlimited uses for permanent magnets as yet undiscovered.

In specializing in permanent magnets since 1910, we have discovered and engineered many advances in magnetic technology with the result that this company is now the largest in the country manufacturing permanent magnets exclusively.

If you are making products which might function better through the employment of magnetic energy, our engineers will be pleased to consult with you. Write for complete information. Ask for a copy of *"Permanent Magnets Have Four Major Jobs."*

THE INDIANA STEEL PRODUCTS COMPANY

6 NORTH MICHIGAN AVENUE • CHICAGO 2, ILLINOIS

ARMY E NAVY

Specialists in Permanent Magnets Since 1910

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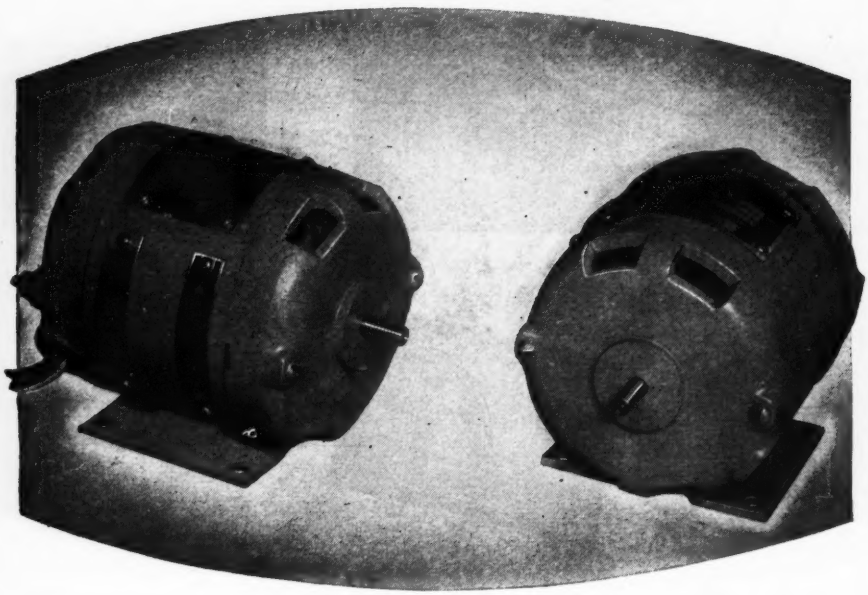
OHIO
MOTORS for ELECTRONIC APPLICATIONS



1/75 HP—115 V-60 Cy.—1 Ph. 1670 R. P. M.—Clockwise, Ball Bearing, Ventilated.

●

Cut shows one of many types and sizes of Ohio Motors designed for driving Electronic Devices.

RANGE

1/100 to 2 HP.—A.C.
1/100 to 1 HP.—D.C.
1/100 to ¼ HP.—A.C. Synchronous.
1 to 100 oz. ft. A.C. Torque.
Shell type motors for built-in applications to 4 HP.—D.C. and to 7½ HP.—A.C.
All usual voltages and cycles.

What is your problem?

THE OHIO ELECTRIC MANUFACTURING CO.
5908 Maurice Avenue Cleveland 4, Ohio

Light Aircraft Meeting, Detroit, Mich. Meetings Committee, 1505 RCA Building West, 30 Rockfeller Plaza, New York 20, N. Y.

WASHINGTON NEWS

VICTORY-FIRST PRODUCTION. "Reconversion" and "cutbacks" were described by Director Louis J. Chatten of the Radio and Radar Division, WPB, as two bugaboo words standing in the way of increased Victory-First production of electronics in industry, when he spoke before a recent RMA export committee meeting. As he pointed out, publicity has made the two subjects more interesting reading than the war news.

Production reports for October show communication and electronic equipment up 5 percent over September, but still 6 percent short of schedule. Radio equipment output equaled September production but was 7 percent under schedule, while airborne radio production for the Army was up 12 percent and only 3 percent short of schedule. Radar equipment production was up 4 percent but still lagged 8 percent behind schedule.

The new Victory-First production program faced by the radio and radar industry calls for maximum peak production of over-all products and equipment at the rate of $250,000,000 a month by March 1, 1945. WPB announces plans to undertake immediately a survey of the industry aimed at establishing a factual background covering production, labor, and other elements related to the industry's ability to get increased production.

Shortages of radio receiving tubes for the maintenance of Army and Navy combat equipment and replacement of increasing battle losses must be made up at the expense of civilian radio tube supplies, it was announced, and therefore the number of civilian tubes available in the first quarter of 1945 will be much smaller than the hoped-for 2,000,000 tubes a month.

NON-CRITICAL COMPONENTS. Regulations of WPB have been relaxed to make it possible to buy a number of types of parts and components out of idle and excess stocks of war contractors. Items no longer con-

STRAIGHT TO THE MARK!

Our Navy's PT Boats are driving the war home to the enemy at high speed. They're shooting straight to the mark! They're demonstrating the power of American ingenuity and industry to the Jap war lords!

Eastern is serving on board these scrappy, hard-hitting PT Boats. Eastern equipment helps them carry out each assignment—swiftly and surely. Amplifiers, only a few short years ago, were thought of mainly in connection with sound systems. Today, they are an important part of many essential war instruments.

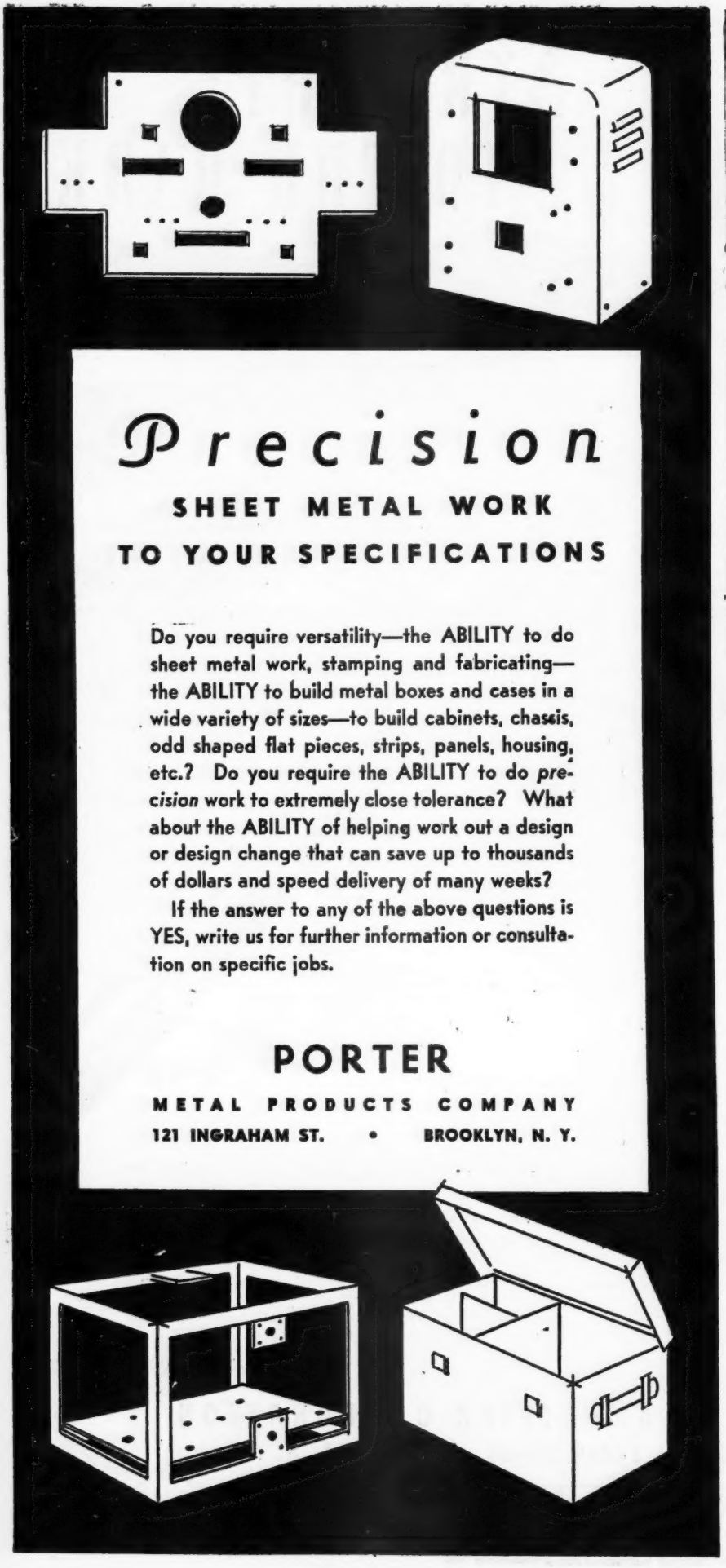
Eastern is proud to utilize its engineering and production facilities in the war effort . . . certain that its war-time experience will result in better-than-ever post-war sound and electronic equipment. Until the victory is won, Eastern will continue to devote all its resources to the design and manufacture of war equipment. To aid the war effort, our engineers are available for consultation on any amplification problem you may have.

On request, we shall be glad to forward brochure containing the first of a series of articles covering technical phases of interest on sound amplification prepared by our engineering staff. Ask for Brochure **2-F.**

Buy MORE War Bonds

EASTERN AMPLIFIER CORPORATION
794 East 140th Street, New York 54, N. Y.

EASTERN AMPLIFIERS


Precision
SHEET METAL WORK
TO YOUR SPECIFICATIONS
Do you require versatility—the ABILITY to do sheet metal work, stamping and fabricating—the ABILITY to build metal boxes and cases in a wide variety of sizes—to build cabinets, chassis, odd shaped flat pieces, strips, panels, housing, etc.? Do you require the ABILITY to do precision work to extremely close tolerance? What about the ABILITY of helping work out a design or design change that can save up to thousands of dollars and speed delivery of many weeks?
If the answer to any of the above questions is YES, write us for further information or consultation on specific jobs.
PORTER
METAL PRODUCTS COMPANY
121 INGRAHAM ST. • BROOKLYN, N. Y.

sidered critical include certain capacitors, some types of resistors, crystal assemblies, insulators, microphones, sockets and loudspeakers.

AIRPORTS PLANNED. Prepared by the Civil Aeronautics Administration, a national airport plan has recently been sent to Congress by the Secretary of Commerce. The report recommends construction of 3,050 airports and improvement of 1,625 existing fields. Construction is to be financed over a period of five to ten years by federal aid with matching of funds by the state. Radio facilities will be included with other items to a total of $1,021,567,945.

RECEIVING-TUBE SCHEDULING. Headed by Milton Lauer of the Radio and Radar Division, WPB, as government presiding officer, the following individuals constitute the newly-appointed receiving-tube-scheduling industry advisory committee: William Hieatt, Ken-Rad Tube and Lamp Corp.; G. C. Brewster and L. F. Holleran, RCA; Ray Paret, National Union Radio Corp.; K. Johnson and F. E. Anderson, Raytheon Mfg. Co.; John Q. Adams, Hytron Corp.; K. Morehead and H. W. Van Twistern, Tung-Sol Lamp Works; H. J. Klein and A. L. Milk, Sylvania Electric Products.

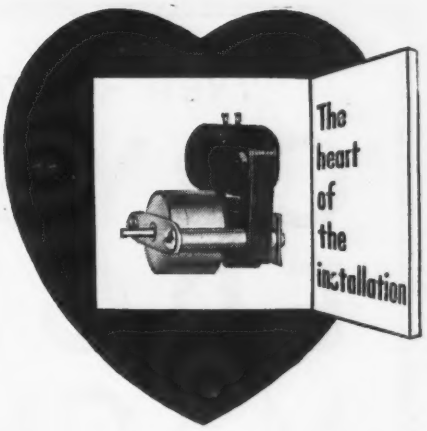
LONDON LETTER

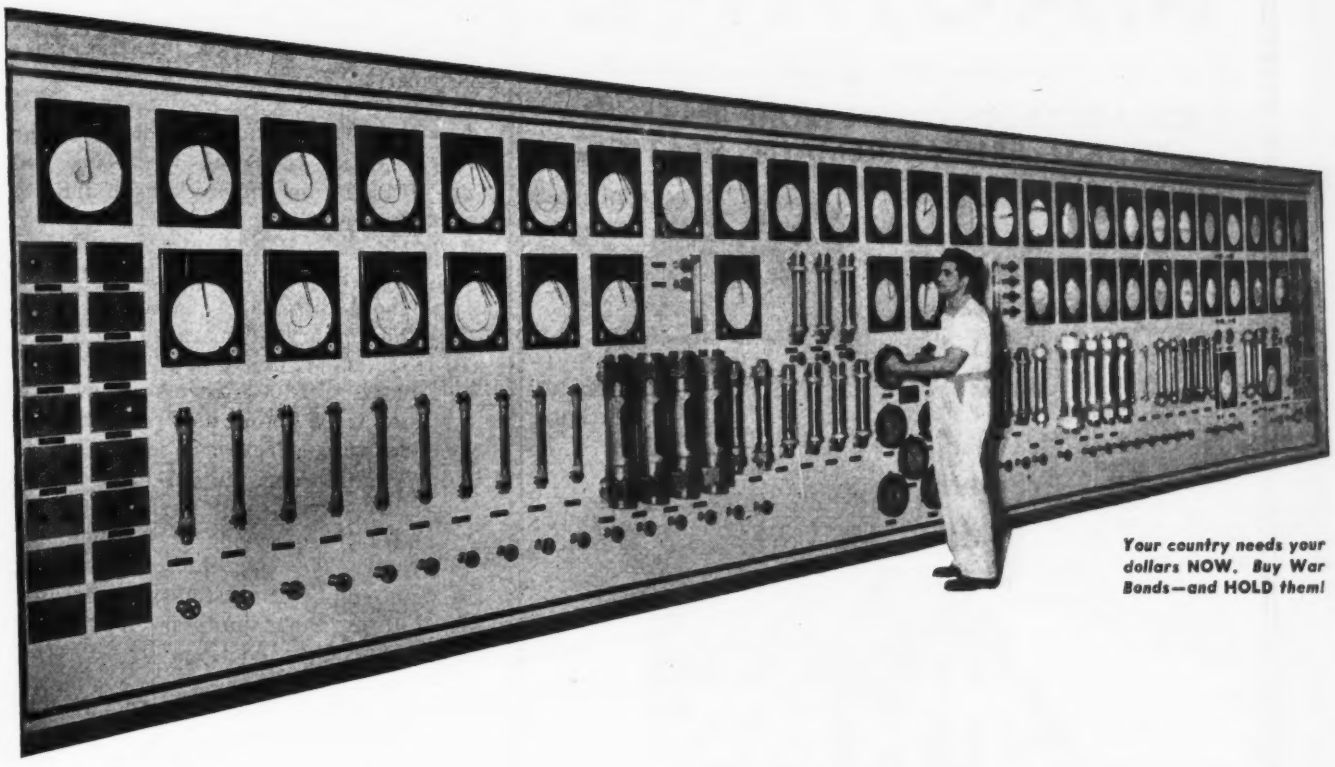
By JOHN H. JUPE

ELECTRONIC OPPORTUNITIES FOR EX-SERVICEMEN. Many men leaving the technical branches of the fighting services will want to use their newly acquired technical knowledge as a means to earn a living and some opportunities for development in the science of cinematography were mentioned by Mr. A. G. D. West in his presidential address to the British Kinematograph Society recently. All were electronic and they included problems of theatre acoustics, uniformity of sound reproduction, uniform screen brightness, maintenance of quality in recording, and improvements in 16-mm sound film.

Another field in which electronic research is badly needed involves the quality of sound in the various types of office dictation recorders used by business men. Without ex-

SPEEDING SPIRITS FOR WAR USE WITH TELECHRON MOTORS





Your country needs your dollars **NOW.** *Buy War Bonds—and* **HOLD** *them!*

WHEN war called for greatly increased supplies of industrial alcohol, installation of this control panel helped a midwestern distillery to step up its production of high-proof spirits. These control instruments made possible the quick conversion of a low-proof distillate tower to production of 190-proof alcohol.

Each of the recording and controlling instruments is driven by a *synchronous, self-starting Telechron motor.* They record and control the feed to the tower, the steam used in distillation, temperature of the cooling water, and the vacuum in the tower. Their smooth, constant speed keeps the distillation process at peak efficiency—around the clock.

Telechron motors are available in sizes from 12 to 250 volts for all commercial frequencies—and from 1 to 1800 rpm. Accurate, dependable and flexible, they are used in all kinds of industrial operations. Their applications include:

TIMING	*CYCLING OPERATIONS*	*MEASURING*
CONTROLLING	*SIGNALING*	*GAGING*
METERING	*FIXED PROCESS CONTROLLING*	*REGULATION*
RECORDING		*COMMUNICATIONS*
SWITCHING		

Our more than 25 years' experience in making synchronous, self-starting motors for instrumentation is available to you for the asking. Just write Motor Advisory Service, Dept. C.

Telechron

REG. U. S. PAT. OFF.

WARREN TELECHRON COMPANY • ASHLAND, MASSACHUSETTS

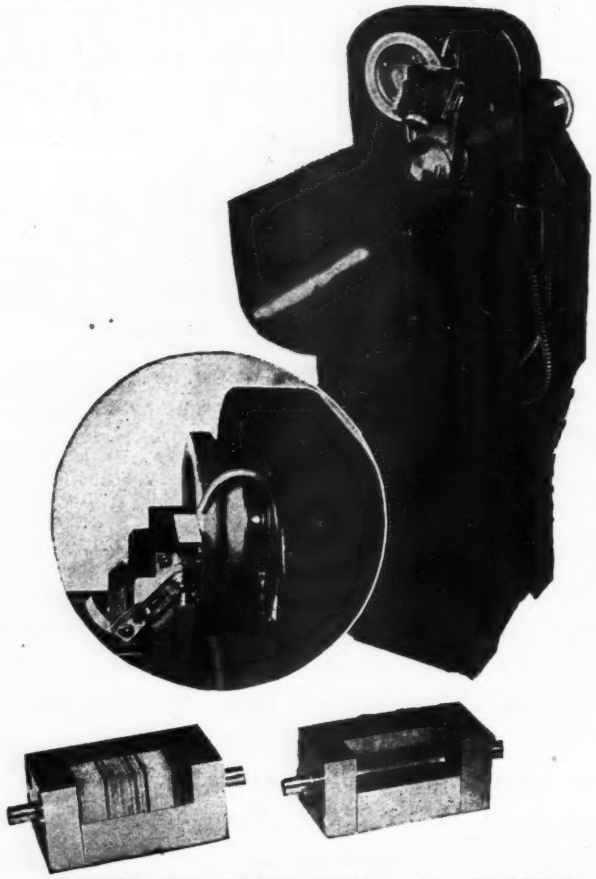
MAKERS OF TELECHRON ELECTRIC CLOCKS AND SYNCHRONOUS ELECTRIC MOTORS

New - Sensational

CRYSTAL EDGING MACHINE

Pre-Dimensional

INCREASE PRODUCTION MORE THAN 50%
— YOUR OVERHEAD REMAINS STATIC —



★ WRITE TODAY FOR DETAILS AND PRICES ★

VOLKEL BROS.
MACHINE WORKS

1943 West Manchester · Los Angeles 44, Calif.

Designers and Manufacturers of
SPECIAL DEVICES & EQUIPMENT

ception, the a-f response is very bad (apart from other faults) and it is high time that something was done in the matter, because here is the ideal way of showing the business man exactly what electronics can do.

BUSINESS NEWS

UTAH RADIO PRODUCTS COMPANY'S subsidiary, Caswell-Runyan Co., Huntington, Ind., has purchased property and equipment formerly owned by the Goshen Veneer Co. for the production of panels and related items to go into radio receivers.

KEN-RAD CORP. has sold its tube facilities at Owensboro, Ky., and Huntington and Rock Port, Ind., to General Electric Co.

ST. JOHN X-RAY SERVICE INC., Long Island City, N. Y., marks its 20th anniversary of operation.

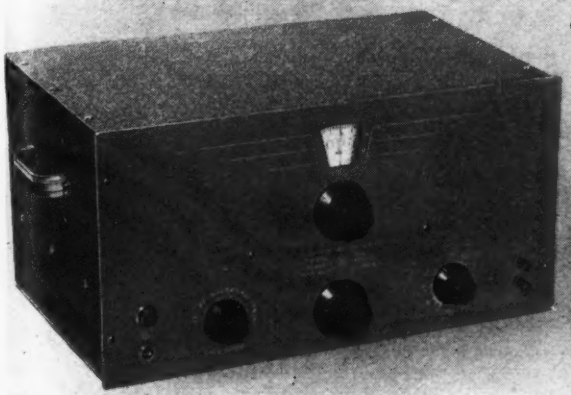
PRESS WIRELESS forms a new division to be known as Press Wireless Institute. Previously operating as a Signal Corps radio school, the facilities are now being used for instruction of seamen from the U. S. Navy. The curriculum places special emphasis on high-power transmitter work, antenna technique, and trouble shooting.

ELECTRONIC CORP. OF AMERICA, United Transformer Co., and Emerson Radio and Phonograph Co., New York, N. Y., participated through joint labor-management activities in a special program for distribution of Christmas gifts to Russian children.

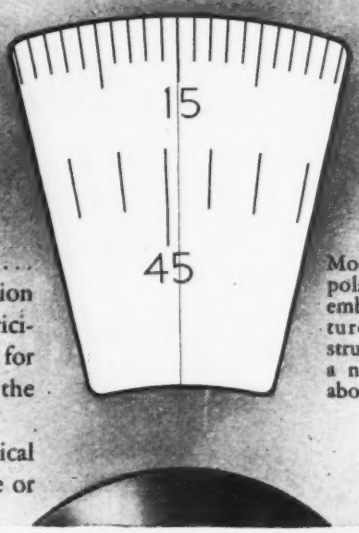
GENERAL ELECTRIC X-RAY CORP. enlarges its Chicago facilities by the addition of 12,000 square feet of floor space at 1417 West Jackson Blvd. Tube laboratories which had previously been scattered throughout the company's main plant, will be housed here as a centralized experimental section.

WAR PRODUCTION BOARD statistics compiled from about 10,000 reports from private and government-owned manufacturing plants indicate that the first quarter of 1944 saw communication and electron equipment shipped to the extent of

A LIFETIME of SPLIT-HAIR ACCURACY *is Standard Equipment with Every -hp- Instrument*



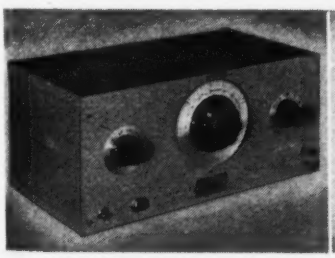
MODEL 200-I



"Guess-testing" belongs to the era of crystal sets and silent pictures... Radio and electronics of today *and tomorrow* demand the use of precision testing and measuring instruments. Hewlett-Packard engineers anticipated this demand. There is a standard *-hp-* instrument available for making every important test and measurement *with insured accuracy* in the audio frequency field.

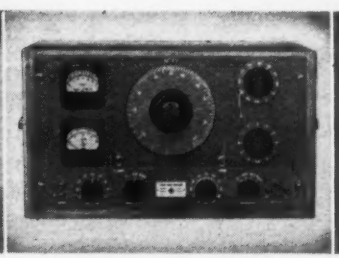
A few of these instruments are illustrated below... complete technical information will be sent on request. For special applications, a note or sketch outlining your problem will receive prompt attention.

Model 200-I is a new interpolation oscillator which embodies many new features. New, rugged construction, new circuit and a new accurate dial. Ask about it.



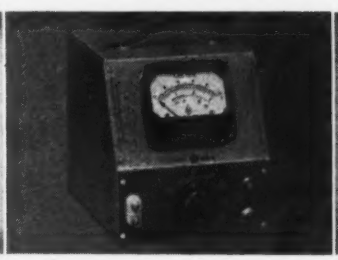
RESISTANCE-TUNED AUDIO OSCILLATORS

Require no zero setting...several models available to cover frequency ranges from 2 cps to 200 kc.



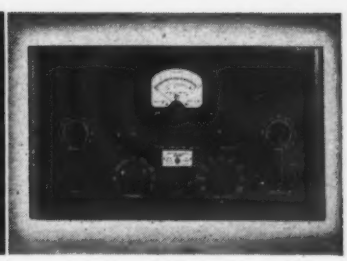
AUDIO SIGNAL GENERATORS

Three models—205-A, 205-AG, 205-AH—provide frequency ranges from 20 cps to 100 kc.



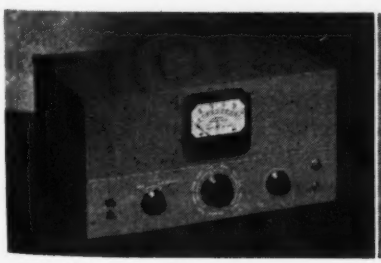
VACUUM TUBE VOLTMETERS

Make accurate voltage measurements from 1 cycle to 1 megacycle, cover nine ranges, (.03 volts to 300 volts) with full scale sensitivity.



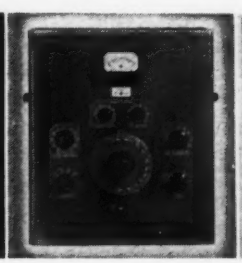
DISTORTION ANALYZERS

Three models available—320-A, 320-B and 325-B—to provide frequency coverage from 30 cps to 15 kc. Model 325-B incorporates a vacuum tube voltmeter.



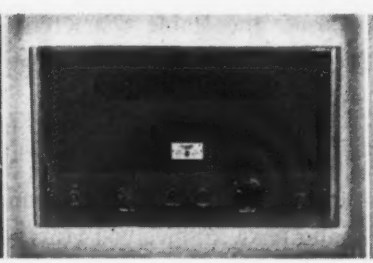
ELECTRONIC FREQUENCY METER

The Model 500-A is designed to measure the frequency of an alternating voltage from 10 cps to 50 kc. Overall accuracy is ± 2% of full scale value.



HARMONIC WAVE ANALYZER

Measures individual components of a complex wave over a frequency range of 30 to 16,000 cps. The selectivity can be varied continuously, making the analyzer adaptable to a wide variety of measurements.



FREQUENCY STANDARDS

The Model 100-B supplies standard frequencies of 100, 1,000, 10,000 and 100,000 cps, all of which are available simultaneously.

ATTENUATOR AND VOLTAGE DIVIDERS

The Model 350-A consists of a 10 db and a 100 db bridged-T attenuator, providing a total of 110 db attenuation, variable in 1 db steps. Other attenuators and voltage dividers can be quickly supplied.

HEWLETT-PACKARD COMPANY

BOX 990A, STATION A — PALO ALTO, CALIFORNIA

990

CANADIAN OFFICE:
560 KING STREET WEST
TORONTO 2, CANADA

AGE is important

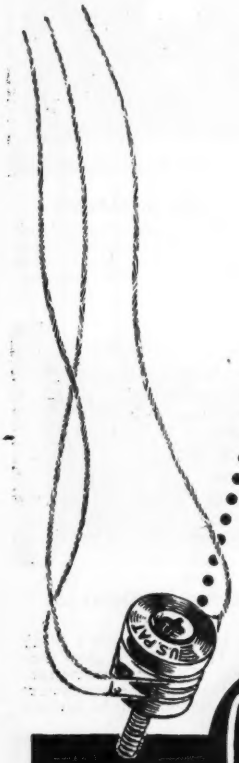
in fine violins...

and in fine rectifiers

While some ordinary rectifiers require a period of "ageing," under operating conditions, to attain the stable characteristics necessary for correct instrument applications, this is *not* true of the CONANT family of rectifiers.

CONANT rectifiers, when they reach you, have already "become of age," electrically. Part of the CONANT process is devoted to developing, by chemical means, the stable characteristics ordinarily secured by a time-consuming "ageing" period.

Yet, despite their "ripe old age," you'll be amazed to find CONANT rectifiers surprisingly "spry" and ready to give you years of reliable service. For your present needs or your postwar plans, you can COUNT ON CONANT.



Instrument Rectifiers

CONANT ELECTRICAL LABORATORIES

6500 O STREET, LINCOLN 5, NEBRASKA, U. S. A.

20 Vesey St., New York 7, New York
85 E. Gay St., Columbus, Ohio
600 S. Michigan Ave., Chicago 5, Ill.
1215 Harmon Pl., Minneapolis 3, Minn.
2017 Grand Ave., Kansas City, Mo.
7935 Eustis St., Dallas 18, Texas
4018 Greer Ave., St. Louis, Mo.
1526 Ivy St., Denver, Colo.
4214 Country Club Dr., Long Beach 7, Cal.
4205 N.E. 22nd Ave., Portland 11, Ore.
Caixa Postal 930, Sao Paulo, Brazil
50 Yarmouth Rd., Toronto, Canada

$1,049,298,000 involving 34,475 short tons of carbon steel, 10,614 short tons of alloy steel, 28,941,000 lb of copper and copper-base alloys; and 11,166,000 lb of aluminum.

PERMOFLUX CORP. consolidates its engineering and manufacturing facilities at 4900 West Grand Ave., Chicago 39, Ill.

WESTERN ELECTRIC CO., New York, N. Y., plans to manufacture television transmitting equipment post war.

PEERLESS ELECTRICAL PRODUCTS CO., Los Angeles, Calif., has installed the first complete hydrogen annealing plant in the West for treatment of high permeability materials going into wide-range audio transformers.

HARVEY MACHINE CO. Inc., Los Angeles, Calif., has developed a miniature six-tube receiver for post-war distribution. It is described as about the size of three packages of cigarettes—neither being currently available.

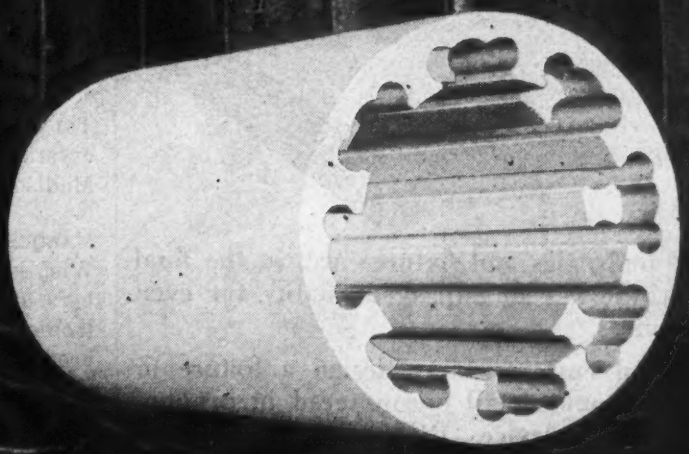
PHILCO CORP., Philadelphia, Pa., is cooperating with the Massachusetts Institute of Technology on plans for a professional course in electronics. The new cooperative course, which leads to a master of science degree, will emphasize the advancement of television and highly developed production methods in applying wartime techniques to the arts of peace.

ASSOCIATION OF AMERICAN RAILROADS is forming a central radio- and communications-engineering and technical committee to coordinate frequency needs. The committee will maintain liaison for all member roads with FCC.

INDUSTRIAL ELECTRONICS, Detroit, Mich., and Visual Training Corp. are forming a combined school to give instructions in electricity and electronics. Students will be offered two-year engineering courses or short specialized training periods for specific industrial positions.

ATLAS CORP. acquires an interest in the Societe de Gerance de Radio Imperial of Tangiers. The plan is

Adaptability in CERAMICS



COIL FORM FOR INTERNAL WINDING by STUPAKOFF

Permanently strong and stable both mechanically and electrically, ceramics are versatile materials capable of intricate design. Competent engineering enables dimensional tolerances to be held to a minimum.

The internally wound coil form illustrated is engineered and produced by Stupakoff for a specific application. Resistance to thermal shock and mechanical strength are specifications embodied in this one-piece extruded insulator. Slotted, longitudinal winding holes expose the heating element and allow heat to be directed instantaneously to the center of the coil.

Specialists in the field of electrical insulation, Stupakoff engineers are trained to find *specific* solutions for *your* insulation problems. Contact Stupakoff today —two generations of dependability in the ceramic field justify this choice.

STUPAKOFF CERAMIC AND MANUFACTURING CO., LATROBE, PA.

Ceramics for the World of Electronics

IN PLATING IT'S THROWING POWER THAT COUNTS

PALLITE TRADE MARK

PALLADIUM PLATING SOLUTION

has tremendous throwing power.

The affinity of palladium for other metals means it can be plated with ease on lead solder, tungsten, tantalum, silver, etc., and, if required, other metals, such as gold, copper, etc., can be plated over PALLITE. Without any difficulty, palladium from a PALLITE bath can be deposited into the most remote corners.

Palladium is a sister metal of Platinum, and in the electronics field a flash deposit of .000001″—.00001″ can often replace many metals now being used. A film of palladium .000001″ from our PALLITE bath will protect silver from tarnishing and will maintain the Q value in high frequency electronic equipment without imparting measurable resistance characteristics to the silver. Palladium is highly resistant to corrosion at elevated temperatures as well as at low temperatures. Our bath is easy to use and economical.

Bring your plating problems to us; let us tell you how a leading manufacturer of electronic parts has been using PALLITE successfully for almost 2 years.

PALLITE

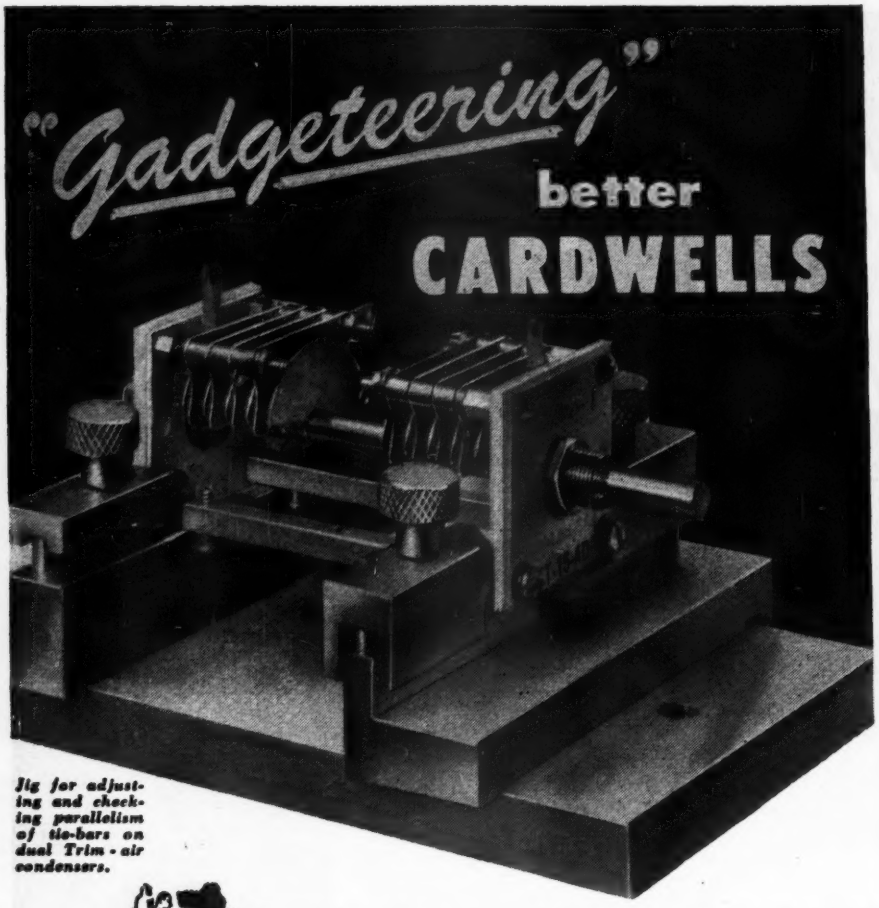
is made only by

PRECIMET LABORATORIES

Division of GEORGE C. LAMBROS

Research and Development in Precious Metals

64 Fulton Street **New York 7, N. Y.**



Jig for adjusting and checking parallelism of tie-bars on dual Trim-air condensers.

Special tools, jigs and fixtures are, in the final analysis, the key to improved quality for even the simplest devices. ●

Sometimes a good customer may design a fixture to improve a troublesome detail encountered in production use of one of our devices. RCA "gadgeteered" this assembly jig which insures parallel and co-planar tie-bars on dual Trim-air condensers.

●

We appreciate such cooperation because we are doing plenty of "gadgeteering" ourselves—some of it very complicated—and the obvious is sometimes overlooked.

●

Whether it is an automatic "gadget" such as Cardwell developed to electronically calibrate, and mechanically print, more than 3000 points on each of the thousands of Cardwell Frequency Meters (used by our Armed Forces), or the relatively simple device shown here, Cardwell products reflect, in improved quality, the application of intelligent "gadgeteering". This is passed on to all users of

CARDWELL QUALITY PRODUCTS

CARDWELL CONDENSERS

THE ALLEN D. CARDWELL MANUFACTURING CORPORATION

81 PROSPECT STREET BROOKLYN 1, N. Y.

to build and operate broadcasting, television, wireless-communication, and facsimile-transmission facilities in such French points as Martinique, French Guiana, Guadeloupe, territories in India, Madagascar, la Reunion, New Caledonia, Oceanic Settlements, Clipperton Island, and St. Pierre et Miquelon.

RCA PHOTOPHONE EQUIPMENTS LTD., Bombay, India, has a far-reaching postwar program for expansion of India's film industry. Opportunities are spotlighted by the fact that India's 390 million inhabitants are served by only 1700 film houses as compared with 17,000 in this country of 130-million population.

THE 1350 SIXTH AVE. CORP., New York, N. Y., is planning what it believes to be the first theater in the U. S. to be built and equipped for projection television.

TELICON CORP. has opened a second crystal-finishing plant at 70th and Madison Ave., New York, N. Y.

MARQUETTE UNIVERSITY, Milwaukee, Wis., has 80 electrical union members studying in the special electronics course they are giving to produce better electricians. Instruction is to be given to 500 similar students who will carry their enlightenment back to the local organizations.

WESTERN ELECTRIC CO., New York, N. Y., is observing its 75th anniversary. It currently employs nearly 100,000 men and women and is the Nation's largest producer of communications and electronic equipment for the armed forces.

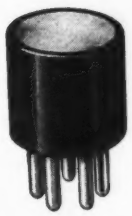
EMERSON RADIO AND PHONOGRAPH CORP., New York, N. Y., disbursed approximately $149,000 to workers as a year-end bonus.

HOLTZER-CABOT ELECTRIC CO., Boston, Mass., has sold its signal systems department to Faraday Electric Corp., Chicago, Ill. Holtzer-Cabot is a wholly-owned subsidiary of Commercial Investment Trust Corp.

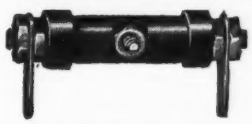
PHILCO CORP., Philadelphia, Pa., has made 52 percent more radar and other electronic equipment in the first nine months of 1944

NEW RECTIFIERS FOR SIMPLIFICATION OF CIRCUIT DESIGN PROBLEMS

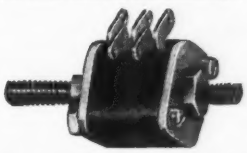
STANDARD MODELS OF COPROX RECTIFIERS



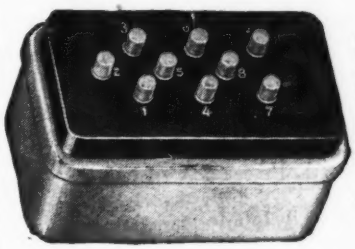
Coprox Model CX-2E4-A9, ring-connected and mounted in tube base, detects phase differentials in A.C. currents and small D.C. potentials applied to balanced A.C. circuits. Maximum 4.5 volts continuous. Shown here in actual size.



Coprox Model CX-1C2B1, a center tap, full wave rectifier. Completely enclosed in Bakelite. Low capacitance. Rectifies high frequency current. Conservatively rated up to 4.5 volts A.C., 3.0 volts D.C., 500 microamperes D.C. Other models and capacities to meet all needs.



Coprox Model CX-4D4F23, a full wave rectifier with high conversion efficiency, for electronic control work. Rated at 5 volts A.C., 40 milliamperes D.C. continuous. Fully enclosed. Mounts on a single screw.



Coprox CX-3E8C3 double bridge rectifier with current and temperature current characteristics balanced to better than 1% over a range of —40°C to +70°C. Rated up to 4.5 volts A.C., 3 volts D.C. 5 milliamperes D.C. Other models and capacities to meet all needs

Coprox CX-2E1H5 (Not illustrated) Single half-wave rectifier rated up to 4.5 volts A.C., 3.0 volts D C., 2.5 milliamperes D.C.

Coprox CX-2E4F2 (Not illustrated) Full wave rectifier rated up to 4.5 volts A.C., 3.0 volts D.C., 5 milliamperes D.C.

Coprox CX-2E2D4 (Above) Double half-wave rectifier rated up to 4.5 volts A.C., 3.0 volts D.C., 2.5 milliamperes D.C.

Many variations are possible with the basic Coprox Rectifier models described at the left. Bradley's application experience can help you, not only in the use of these units but also in the development and production of special rectifiers for special jobs. Here are the special features of all Bradley Coprox Rectifiers:

- *Gold coating of "pellets" to combat aging.*
- *Pre-soldered lead wires, or special terminals, to prevent overheating during assembly.*
- *High leakage, low forward resistance, for efficient operation.*
- *Waterproof lacquering or wax potting, for perfect sealing.*
- *Highly adaptable mountings.*
- *Ratings are very conservative.*

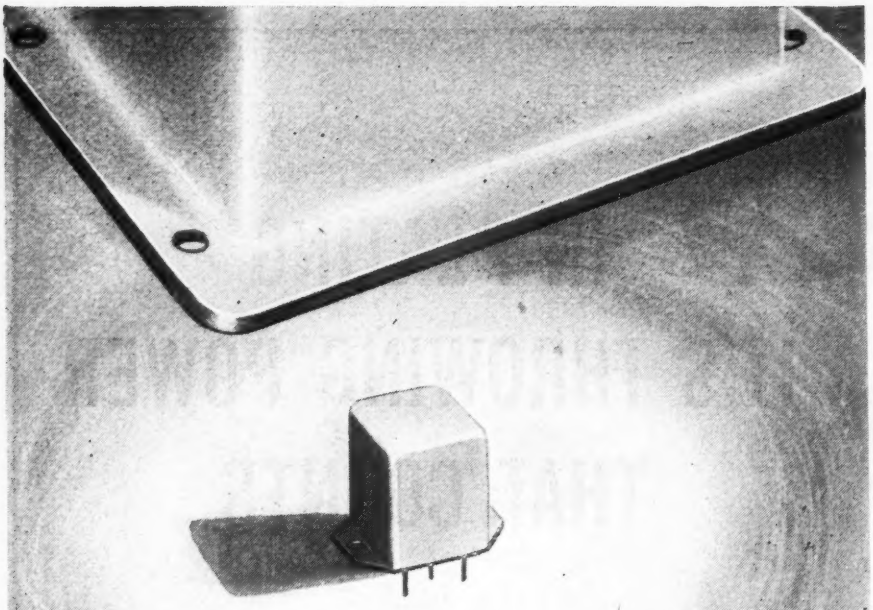
For samples and special data which will help you design more efficient circuits that will stand up longer than others, write Bradley. Ask any questions you have in mind.

LUXTRON PHOTOCELLS

A Bradley booklet is available, to suggest the many ways in which Luxtron* photocells can be used for control and testing purposes. These cells generate sufficient current to operate instruments and instrument relays without amplification. They, too, are built for long life and have varied mountings and a wide range of sizes. (*Trade Mark Reg. U. S. Pat. Off.)

BRADLEY LABORATORIES, INC.

82 MEADOW ST., NEW HAVEN 10, CONN.



Superiority
IN A MIDGET!

Permoflux Transformer Efficiency Conserves Vital Space and Weight!

The urgent requirement for light weight war communications equipment was the challenge that led Permoflux to develop these miracle coupling devices. From the original need of just a few small transformer types combining high performance standards has come acceptance and demand for many. The value of these achievements will mean much to improve the operation of postwar radio and electronic products. Permoflux engineers welcome consultation on all sound design problems.

BUY WAR BONDS FOR VICTORY!

TRADE MARK
PERMOFLUX
PERMOFLUX CORPORATION
4900 WEST GRAND AVE., CHICAGO 39, ILL.

PIONEER MANUFACTURERS OF PERMANENT MAGNET DYNAMIC TRANSDUCERS

than in the same fraction of last year. Earnings are up over the same period from $1.78 to $2.11 per share.

PERSONNEL

HOWARD THOMAS, of Packard Bell Co., is elected president of West Coast Electronics Manufacturers Association. He succeeds H. Leslie Hoffman. Lew Howard of Peerless Electrical Products Co. becomes vice-president and James L. Fouch of Universal Microphone Co., treasurer.

H. B. MARVIN has been made available for special assignments in the tube division of General Electric Co., Schenectady, N. Y. He was formerly assistant engineer in the general engineering laboratory.

W. E. FULLERTON has been made vice-president in charge of production at Zenith Radio Corp., Chicago, Ill.

WINFIELD G. WAGENER is appointed chief engineer of the Vacuum Tube Division, Litton Engineering Lab-

oratories, Redwood City, Calif. He was previously chief engineer for Heintz & Kaufman, Ltd., San Francisco, Calif.

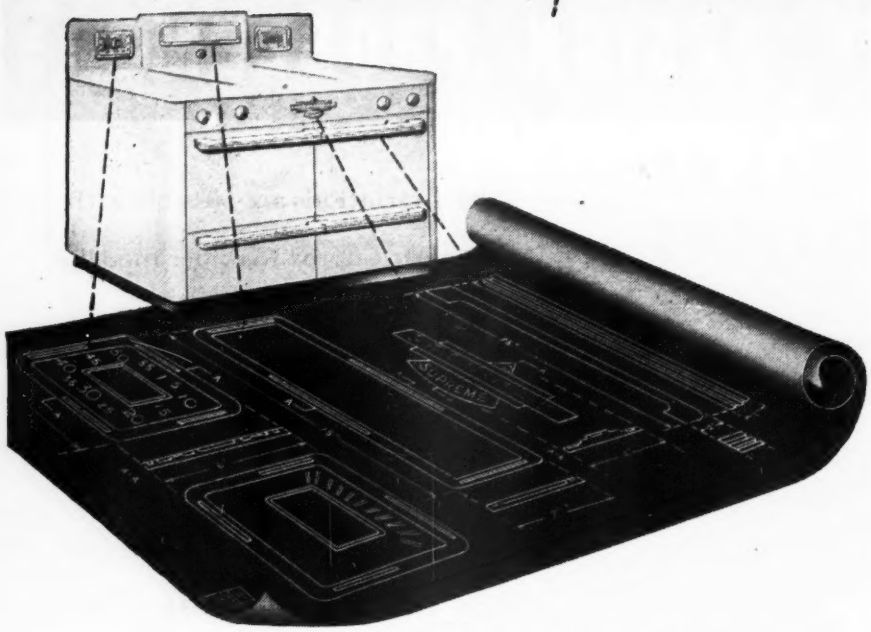
ALVA VAN ALYSTYNE has been made chief transmitter engineer at WMFM, Milwaukee, Wis. He was formerly a transmitter engineer.

STANLEY A. DUVALL has been made chief engineer at Runzel Cord & Wire Co., Chicago, Ill. He was formerly in electronic consultation work.

E. A. HERTZLER has been made director of war research at United Electronics Co., Newark, N. J. He was formerly at Pratt Institute.

HAROLD W. SCHAEFER has been made assistant manager of the ra-

Your POSTWAR METAL PRODUCT *designed and engineered NOW!*



Plan NOW to enlist the aid of GRAMMES Contract Service to develop ideas and blueprint your postwar metal product. The stove trim illustrated is but one of the recent achievements of our designers and engineers . . . other postwar product developments include several radio units, soft drink dispenser, new type snap locknut, parts for refrigerators, giftware, and other consumer and industrial products. These assignments indicate the versatility of our product development staff and how they have assisted others in accomplishing the desired end result.

Since 1875 GRAMMES has collaborated with manufacturing leaders . . . automobile, aviation, radio, refrigerator, and other key industries . . . in creating metal products of distinction. We are specialists in giving products the sales-creating features that flow from "above average" design and decorative beauty of color.

With two "E" awards, we're producing for Victory, but our Contract Service offers Research, Design, and Engineering aid NOW. Improved production techniques and increased plant facilities enable us to handle a few additional accounts requiring volume production for eventual postwar manufacturing.

GRAMMES FACILITIES INCLUDE

Stamping, Drawing, Spinning, Etching, Embossing, Lithographing, Enameling, Hard Enameling, Plating, Spraying, Wire Forming, Drilling, Welding, Machining, Heat Treating, Anodizing (Alumilite), Tools & Dies and Line Assembly.

Send for booklet describing "Contract Service by Grammes."

Two Awards
More Than a Billion Pieces of War Products

Grammes

MASTER CRAFTSMEN IN METAL . . . SINCE 1875

L. F. GRAMMES & SONS, INC., 12 Union St., ALLENTOWN, PA.

NEW YORK • CHICAGO • DETROIT • CLEVELAND • MILWAUKEE • PHILADELPHIA

dio receiver division at Westinghouse Electric & Mfg. Co. He was formerly in charge of radio and television manufacture at Radio Corp. of America.

PHILIP LAESER has made f-m-television engineering supervisor at WMFM, Milwaukee, Wis. He was formerly transmitter supervisor.

DR. DONALD B. SINCLAIR becomes assistant chief engineer in charge of circuit development at General

Radio Co., Cambridge, Mass. Before joining GR in 1936, he was a research associate at MIT.

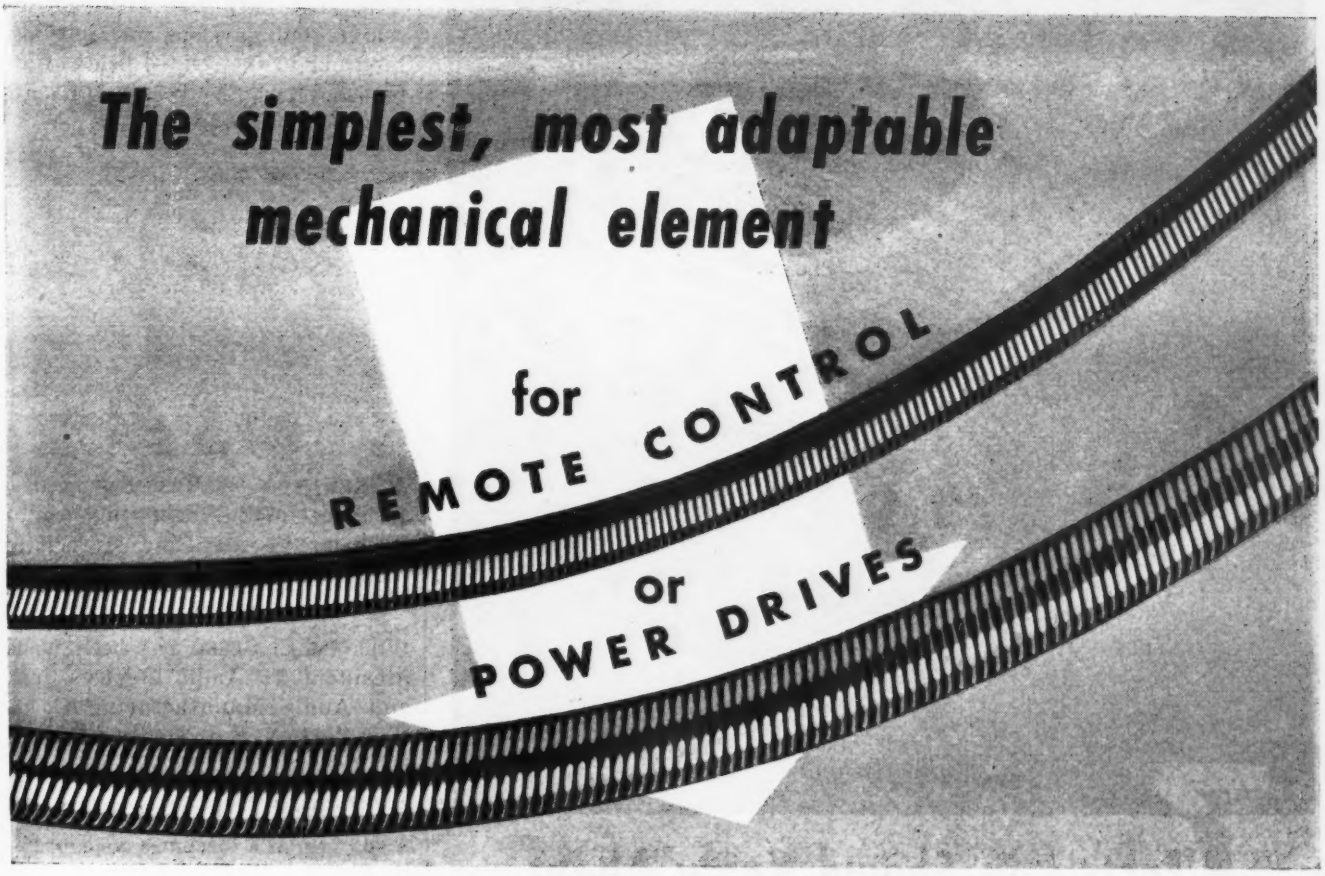
J. R. DUNCAN has been made chief television engineer at WLW, Cincinnati, Ohio. He was formerly active in the building of WLW's present television studios.

E. G. SHALKHAUSER has been made chairman of the Electronic Products and Equipment Manufacturers Association, Chicago, Ill. He is connected with Radio Manufacturing Engineers, Inc., Peoria, Ill.

C. A. CROWLEY has become a mem-

ber of the consulting firm of Graham, Crowley and Associates Inc., Chicago, Ill., and Jenkintown, Pa.

DR. PETER C. GOLDMARK heads the newly created department of engineering research and development at Columbia Broadcasting System, New York, N. Y. With the title of director, he will have the responsi-



S.S.WHITE FLEXIBLE SHAFTS

Regardless of the relative locations of driving and driven or controlled members or of the distance between them, a *single*, S. S. White flexible shaft is all you need to transmit power or remote control from one to the other. This "one-part" simplicity obviously means reduced manufacturing operations and costs.

And because S. S. White flexible shafts will transmit power or remote control between practically any two points, they give you a free hand in placing driving and driven or controlled elements wherever desirable to save space, to facilitate assembly, to increase equipment efficiency and to make equipment convenient to operate and service.

You will find S. S. White flexible shafts suited to a wide range of power drive and remote control requirements because they're made in a wide range of sizes and physical characteristics for each class of duty. Applications are numerous, notably in radio and electronic equipment, aircraft, motor vehicles, machine and portable tools. Industry uses millions of feet annually.

FLEXIBLE SHAFT HANDBOOK FREE TO ENGINEERS

This 256-page handbook completely covers the subject of flexible shafts and how to select and apply them for specific requirements. A copy will be sent free to any engineer who writes for it on his business letterhead and indicates his position or title.

S.S.WHITE INDUSTRIAL DIVISION

THE S. S. WHITE DENTAL MFG. CO.

DEPT. B, 10 EAST 40th ST., NEW YORK 16, N. Y.

FLEXIBLE SHAFTS AIRCRAFT ACCESSORIES
MOLDED PLASTICS
MOLDED RESISTORS FLEXIBLE SHAFT TOOLS

One of America's AAAA Industrial Enterprises

7 Facts You Should Know About C.M.H. *Stainless Steel* Bellows

IF you plan to use bellows for vacuum equipment, instruments, rotating shaft seals, or for other similar purposes in the electronic field, here are some essential features of C. M. H. Stainless Steel BELLOWS:

1. *Corrosion resistant qualities of stainless steel* enable wider application of C.M.H. BELLOWS.
2. *High and low temperatures* do not affect the operating efficiency.
3. *Multiple ply construction* gives even greater strength factors when needed.
4. *Ferrous fittings,* attached by Circular Seam Welding, assure permanent, leak-proof joints.
5. *Uni-metal assemblies* avoid the costly troubles encountered where bi-metal types are used.
6. *Long lengths are standard production* permitting economical use of C.M.H. Stainless Steel BELLOWS for many unusual types of applications.
7. *Better delivery schedules* are possible because C.M.H. BELLOWS are standard production products.

For complete information about C.M.H. Stainless Steel BELLOWS and about the many types of Flexible Metal Hose in the complete C.M.H. line, write us today.

Ask for Chicago Metal Hose Form SSB2 on which to submit your bellows requirements. It will save you time—assure more accurate transmittal of essential data.

Flexible Metal Hose for Every Industrial Use

ARMY E NAVY

CHICAGO METAL HOSE CORPORATION
MAYWOOD, ILLINOIS

Plants: Maywood and Elgin, Ill.

bility not only for television research and development, but also for work in the related fields of antennas, tubes, receivers, and recordings.

A. KENNETH GRAHAM has become a member of the consulting firm of Graham, Crowley and Associates Inc., Chicago, Ill., and Jenkintown, Pa.

WILLIAM C. SPEED has been made president of Audio Devices Inc., and Audio Manufacturing Corp., New York, N. Y. to succeed Hazard E. Reeves. Mr. Speed was formerly vice-president.

A. J. MONACK becomes vice presi-

dent in charge of engineering at Mycalex Corp. of America, New York, N. Y. He was formerly chief engineer.

MAX E. MARKELL, for the past four years chief of the vacuum tube section of the U. S. Signal Corps at

Camp Evans, joins RCA at Harrison, N. J., as a specialist on industrial tube applications.

DR. ERNST FREDRICK WERNER ALEXANDERSON, consulting engineer of General Electric Co., gets the Edi-

You Are Going to Want BROWNING FREQUENCY METERS

How will you have them?

Take this opportunity to name your specific desires . . . to have your own wishes incorporated into equipment you will want to make standard for mobile radio installations.

You will want Browning Frequency Meters because they do what you will want them to do, at a price that will let you use them generously.

Ever since their rapid acceptance several years ago, Browning Frequency Meters have been standard equipment in police and other emergency systems all over the United States.

HERE IS WHAT BROWNING FREQUENCY METERS ALREADY HAVE AND DO:

- Check, with better than .005% accuracy, any five frequencies from 1.5 to 120 Mc.
- Less than a minute required to check any one frequency.
- Pre-calibrated for specific frequencies.
- 100 Kc. crystal oscillator provides at least two check points in any band.
- High dial-reading accuracy achieved by narrow frequency range.
- Cathode ray indicator permits visual check against crystal standard and transmitter.
- Complete voltage stabilization.
- Portable, light-weight, A.C.-D.C. operation.

What More Do You Want?

Certain interesting improvements are already in store for this product of Browning Laboratories research. Whole-hearted devotion of all our energies to war production keeps them in the planning stage. But our postwar thinking, as it takes shape in rough sketches, turns to you — the future owner of future Browning Frequency Meters. We want you to have what you want.

Your letter about what you want in Browning Frequency Meters will receive a cordial welcome. And will, if possible, be reflected in the model delivered to you when we can deliver. Write soon, won't you?

BROWNING
LABORATORIES, INCORPORATED
WINCHESTER, MASSACHUSETTS

Browning Laboratories, Inc.
750 Main Street
Winchester, Mass.

Gentlemen:

Here are the new features I'd like to see in Browning Frequency Meters:

_____

_____

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NAME _____

TITLE _____

COMPANY _____

ADDRESS _____

_____

HERE ARE MY ROUGH SKETCHES

Don't Let The Light Weight Fool You!

Only 14 Ozs. But 225 Watts Power

APPROVED CORD AND PLUG
COOL, PROTECTED HANDLE
WELL BALANCED
THERMOSTATIC HEAT CONTROL
QUICK HEATING ELEMENT
GOOD MODERN DESIGN
6 INTERCHANGEABLE TIPS
FROM TIP TO PLUG . . . IN A CLASS BY ITSELF!

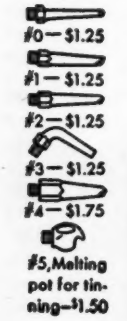
Only the Vanatta Kwikheat has . . .

Built-in Thermostatic Heat Control . . . HOT IN 90 SECONDS

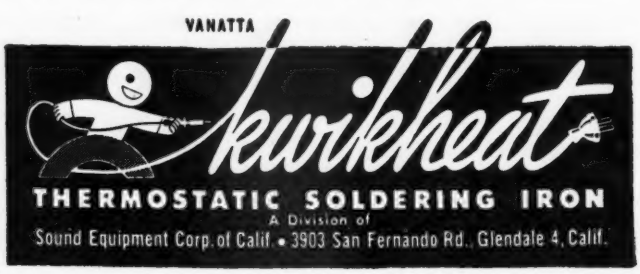
—Built-in thermostat keeps the Kwikheat Iron at correct temperature for most efficient work—can't overheat—saves re-tinning time. It will do jobs of several ordinary irons and do them better! Check these exclusive advantages that put the Vanatta Kwikheat Soldering Iron in a class by itself . . . it's *HOT*, ready to use only *90* seconds after plugging in . . . saves time. Powerful, 225 watts, yet it's light (14 ozs.)—well-balanced. Cool—safe—protected handle. Six interchangeable tip designs enable one iron to do most any soldering job.

Ideal for radio or telephone work. Thousands of Kwikheat Irons in use by some of largest precision manufacturers in nation. Order your Kwikheat Soldering Iron and extra tip styles today from your distributor. Complete iron $11.00 list, includes choice of #0, #1, #2 or #3 tips. AA5, or better, priority required.

6 Tip STYLES



VANATTA


kwikheat
THERMOSTATIC SOLDERING IRON
A Division of
Sound Equipment Corp. of Calif. • 3903 San Fernando Rd., Glendale 4, Calif.

son Medal for 1944 from American Institute of Electrical Engineers for his outstanding inventions and developments in the radio, transportation, marine, and power fields.

A. M. WIGGINS is appointed chief research engineer for Electro-Voice

Corp., South Bend, Ind. He goes there from RCA Laboratories, Princeton, N. J.

MYLES V. BARASCH becomes chief engineer of Sherron Electronics Co., New York, N. Y. He has been with Western Electric Co. in charge of cathode-ray and electron-tube equipment design.

KENNETH MCLEOD takes charge of electronic quality control on the engineering staff of National Union Radio Corp. He has been working on war research at Columbia University, New York.

ROY C. SYLVANDER becomes director of engineering at Bendix Aviation

Corp.'s Eclipse-Pioneer Division, Teterboro, N. J. He has been chief engineer.

V. J. HALL joins the staff of Industrial and Commercial Electronics, Belmont, Calif., as assistant to the chief engineer. He specialized in the development of electronic equipment at Sperry Gyroscope Co.

JOHN M. MILLER JR. becomes chief engineer of United Cinephone Corp., Torrington, Conn. Formerly active in design and development

This Governor-Controlled Oster Motor

Gives You the New Design and Operating Advantages of CONSTANT SPEED

Here is a new Oster development in a constant speed, governor-controlled motor that backs up your good judgment when you specify it for applications where constant speed is a necessity. This motor is now in production and deliveries can be made in the very near future. Here are the features that assure you of satisfaction:

Housing: Die cast aluminum end brackets. Mild steel field housing. Totally enclosed.

Finish: Black anodized end brackets. Cadmium plated field housing.

Weight: 15 Oz.

Bearings: Single shielded ball bearings, lubricated with a grease suitable for any specific application. Bearing housings fitted with steel inserts.

Windings & Insulation: Field coils and armature wound with a select grade of insulated copper wire and impregnated with a high quality heat and moisture resisting insulating varnish.

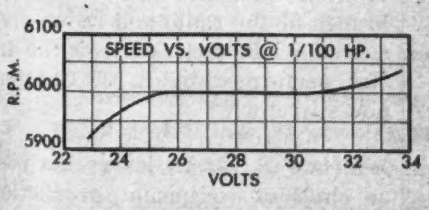
Brushes: Equipped with high grade metal graphite brushes. Beryllium copper brush springs.

Governor: Furnished with a centrifugal governor to maintain constant speed over a voltage range of 25 to 30 volts.

Temperature Rise: Maximum frame temperature rise at rated output will not exceed 55° C.

Modifications: Motors can be furnished with special shaft extensions, mounting arrangements, finishes, leads, etc. All modified units are considered special.

When designing your post-war product, consider this new Oster development in applications where constant speed is a nesessity . . .



Rating of Motor Type BSTG-1A-2

Horsepower—1/100 continuous duty

Speed—6000 R.P.M. ± 1%

Voltage—25-30 volts D.C.

Amps. input—.95

Starting Torque—300% of full load torque

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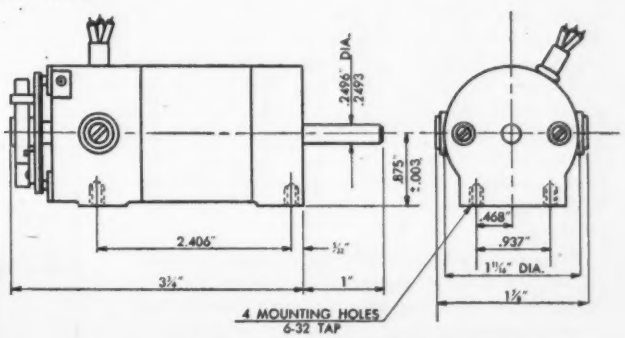
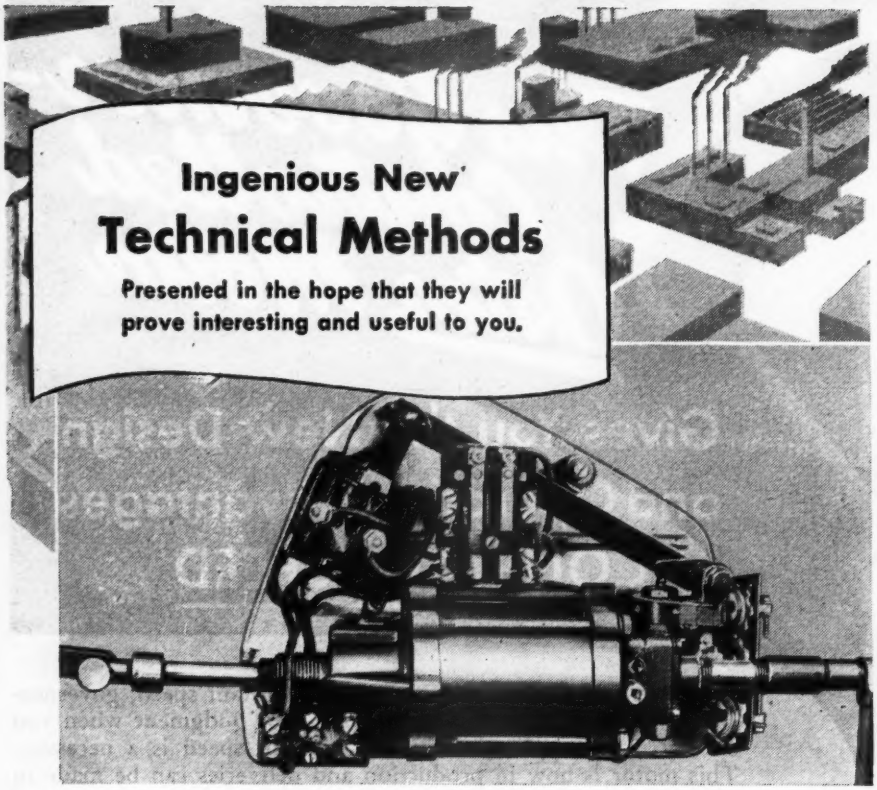


Let us help you fit this and other Oster Motors to your requirements.

M-22

John Oster Manufacturing Co.

DEPARTMENT L-22 • RACINE, WISCONSIN



Ingenious New Technical Methods

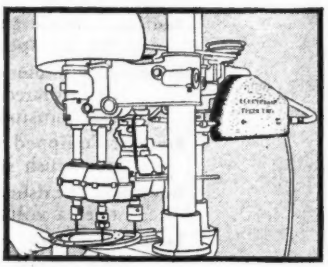
Presented in the hope that they will prove interesting and useful to you.

New Electroaire Power Unit Converts Standard Drill Press to Automatic

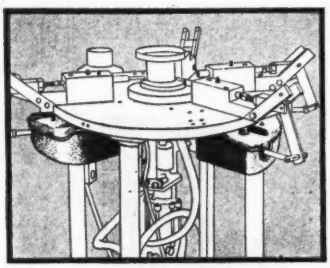
This exact control over feed and retraction speeds permits ready conversion of a standard drill press with tapping head into an automatic tapping machine, capable of producing Class III threads, even with comparatively unskilled operators. By adjusting speed to conform to the lead pitch of the threads being tapped, the tap will cut without forcing threads, and on the reverse the tap will actually "float" out of the part with no strain against the thread angle.

Air-powered jigs and fixtures can be opened, closed, and indexed by the Electroaire Power Feed. The unit can be set for a pre-determined number of cycles so that multiple holes can be drilled in the same piece without ejection, by means of an indexing fixture controlled and synchronized by the Electroaire Unit. One operator can run as many as two or three drill presses, turning out top-quality work with few rejects and with a minimum of tool breakage, thus effecting a great savings in time.

Present stockpiles of finest quality materials used in the manufacture of Wrigley's Spearmint chewing gum are now exhausted —necessitating discontinuance of production. When a supply of proven materials—known to be up to the finest standards of quality—is again available, Wrigley's will resume production—And Wrigley's Spearmint will be back to again help you on your job. In the meantime they are manufacturing a war brand. Wholesome but not excellent enough for the Wrigley brand name.



Set up to punch 3 holes simultaneously



Shows holes being drilled automatically

You can get complete information from Electroline Manufacturing Company, 1975 East 61st Street, Cleveland 3, Ohio

Z-57

work with Philco, the Navy Department, and RCA Victor; Mr. Miller is in full charge of design and development at United.

ELLIOTT R. VINSON, formerly electronic specialist at the U. S. Naval Air Station, Alameda, Calif., is appointed electronic tube specialist for the Pacific Coast District of Westinghouse Electric & Mfg. Co.

ROBERT H. STREETER, newly appointed design engineer at Supreme Instruments Corp., Greenwood,

Miss., has recently gone there from Sparks-Withington Co. where he was a development engineer on automatic direction-finding equipment.

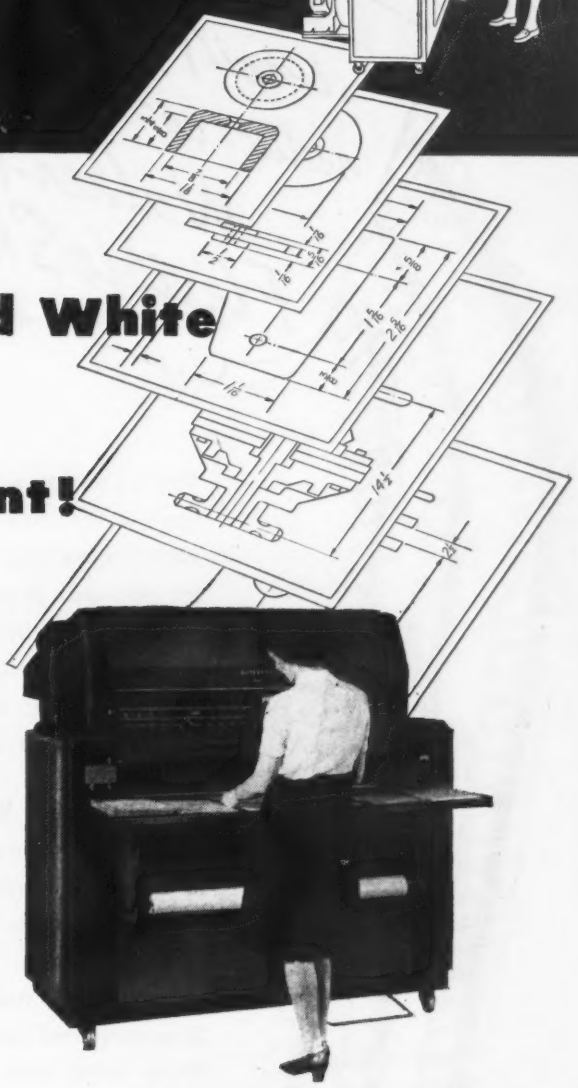
M. E. KARNS, formerly of Radio Corp. of America, becomes chief of the products and facilities branch of the radio and radar division of WPB. He takes over the duties performed by L. J. Chatten, now director.

WILLIAM F. SLOAN leaves his post as chief of equipment production section of WPB's communications division to resume consulting engineering in Chicago, Ill.

DR. JESSE E. HOBSON becomes director of Armour Research Foundation to replace Harold Vagtborg. Dr. Hobson was formerly head of the Electrical Engineering Department at Illinois Institute of Technology.

ALFRED W. PETERSON joins Automatic Electric Co., Chicago, Ill. Formerly chief engineer for the In-

Make Bruning Black and White Prints Right in Your Drafting Department!



Yes—it takes only an area of 61" x 65" to install this Bruning 75-159B Volumatic Printer-Developer! That means you can make Bruning Black and White Prints right in your drafting room—in your engineering department—in a private office! And with this Bruning machine, one person performs the entire printing and developing operation . . . produces BW Prints in large volume on sheets cut to the exact size of your tracings. Remember, BW equipment requires no plumbing.

Decide *now* to have the extra advantages of Bruning Black and White Prints—far easier to read and to check than blue prints! There is Bruning printing and developing equipment for every print production need—whether you make only a few prints a day or hundreds. Find out how easy it is to have BW Prints—mail the coupon for full information.

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Please send me your free booklet giving up-to-date information on Bruning Black and White Prints. I understand there is no obligation.

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MEMO

TO: Postwar Designers

simplify design and reduce costs with Walker-Turner Flexible Shafting!

Reduced production costs is the key to the lower-prices, increased-sales-volume, more-jobs combination needed for post-war prosperity. Walker-Turner Flexible Shafting offers a proven way to bring about this reduction—in products involving remote control or the transmission of light power loads!

By substituting Walker-Turner Flexible Shafting for complicated gear systems in these applications, design is substantially simplified. The product is lighter, more compact. Less material is required. Costly machining is eliminated. Shipping and storage costs go down. Write today and let us put our years of flexible shafting experience to work for you!

WALKER-TURNER CO., INC.
Plainfield, New Jersey

walker-Turner COMPANY INC. PLAINFIELD, N.J. U.S.A.

FLEXIBLE SHAFTING
FOR REMOTE CONTROL AND POWER TRANSMISSION

1F

ternational Telephone & Telegraph Corp. in Puerto Rico, he had recently been with the communications division of WPB.

RAYMOND SOWARD joins Supreme Instruments Corp., Greenwood, Miss., as chief engineer. Formerly

connected with the company as a design engineer, Mr. Soward has recently served with the Signal Corps in Atlanta, Ga.

WILLIAM B. LODGE has been named director of general engineering at Columbia Broadcasting System, New York, N. Y. General engineering activities will include standard broadcasting; f-m and short-wave broadcasting; audio, studio, transmitter, and master control design; and frequency allocations.

DR. W. D. COOLIDGE retires from his post as vice president and director of the research laboratory at General Electric Co., Schenectady, N. Y. Dr. C. G. Suits, formerly assistant to the director, takes charge of the laboratory as a vice president.

AWARDS

Workers of the following concerns in the electronic field have been awarded Army-Navy E burgees for excellence in production:

Automatic Radio Mfg. Co., Inc.
Boston, Mass.
Commercial Radio-Sound Corp.
New York, N. Y.
Noblitt Sparks Industries, Inc.
Franklin, Ind.
Greenwood, Ind.
Regal Electronics Corp.
New York, N. Y.
Times Telephoto Equipment, Inc.
New York, N. Y.
United Electronics Co.
Newark, N. J.

NEW CATALOG

Latest **FM or AM** *Equipment* **RELEASED** *for Police and Fire Stations*

FM or AM *Complete Matched Equipment* **ENGINEERED and BUILT by DOOLITTLE**

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ORDERS ACCEPTED NOW!

YOURS FOR THE ASKING!

Every page contains vital facts you should have to obtain 1945 communication efficiency. Tells all about latest Doolittle STATION TRANSMITTERS — MOBILE RECEIVERS —MONITORS—CONCENTRIC TRANSMISSION LINES—AND ACCESSORIES. Shows the many advantages of modern two-way equipment *. . . completely engineered, built and matched by Doolittle.* Write on official stationery for your copy . . . at once.

Doolittle RADIO, INC.

7421 S. Loomis Blvd., Chicago 36, Ill.

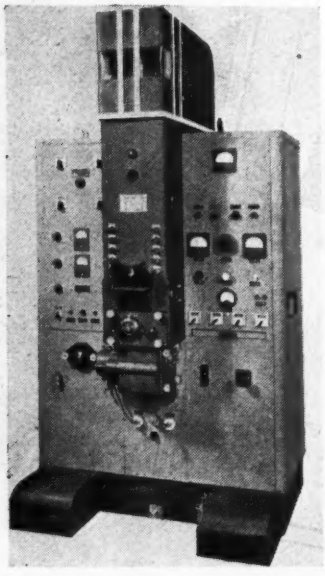
Builders of Precision Radio Communications Equipment

NEW PRODUCTS

Month after month, manufacturers develop new materials, new components, new assemblies, new measuring equipment; issue new technical bulletins, and new catalogs

Electronic Equipment

FOR AIRCRAFT manufacturers, electric power companies and research laboratories, there is available a new self-contained industrial electronic oscillograph which records characteristics of electrical phenomena lasting as little as a fraction of a millionth of a second. The unit consists of the oscillograph proper and a cabinet which houses all energizing and control circuits. An instrument of the cold cathode type, the oscillograph is capable of recording single electrical transients with respect to time, or two electrical phenomena with respect to each other, such as voltage versus current, in the form of diagrams produced by two pairs of electrostatic deflecting plates disposed at right angles to one another. The cathode of the tubes is energized from a 50 kv d-c rectifier with a control to correct for line voltage variation. The beam is normally blocked by a target. An impulse synchronized with the phenomena will trip the relay which bends the beam around the target so that it will strike the fluorescent screen or film below.



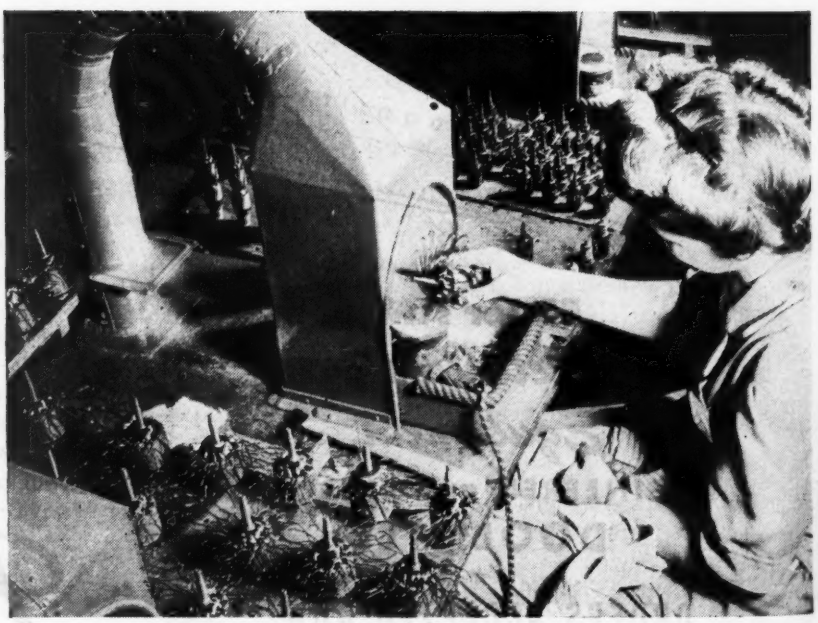
Concentrating coils, beam current meter, and leak valve, control the intensity and size of the trace on the film. Deflecting coils move the zero position of the beam so as to use the whole area of the exposed film for the record. Included with the unit are a fluorescent screen for direct observation, and a stationary film holder which takes a standard film for recording electrical phenomena lasting 1/1000 of a second or less and can be operated with a rotating film drum for phenomena lasting from 1/1000 to 1/10 of a second. A photo-electric control makes it possible to take an oscillogram in one revolution of the drum, regardless of speed. A photoelectric control eliminates the possibility of superimposed waves.

Another product announced by Westinghouse includes a new type of ceramic insulation which is called Zircon porcelain and which is for use in u-h-f equipment. The new material has very low loss at ultra-high frequencies.

Also announced is a new hot-forming molded laminate, known as Micarta 444, which combines the desirable molding properties of thermoplastic materials and the good physical characteristics of thermosetting materials. This new plastic can be heated and pressed into deep-drawn and complicated shapes. Other features of Micarta are good insulating qualities, high impact strength, and good thermal stability.

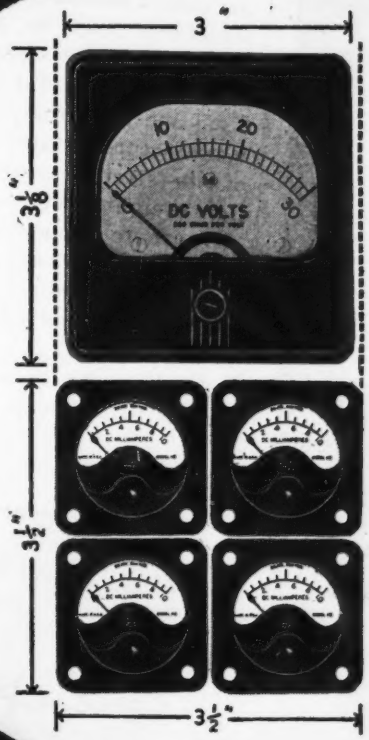
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

WAR SOLDER SPEEDS PRODUCTION



Wire loops on small armatures having their Formex insulation burned off at the same time they are tinned in one Fairchild plant. This is accomplished by heating 60-40 solder to 1,000 deg. F in an electrically-heated pot. The operation formerly required burning off the insulation in an alcohol-lamp flame and wire-brushing before soldering. This took three times as long as the present technique using the war solder

DeJUR DESIGN EFFICIENCY...

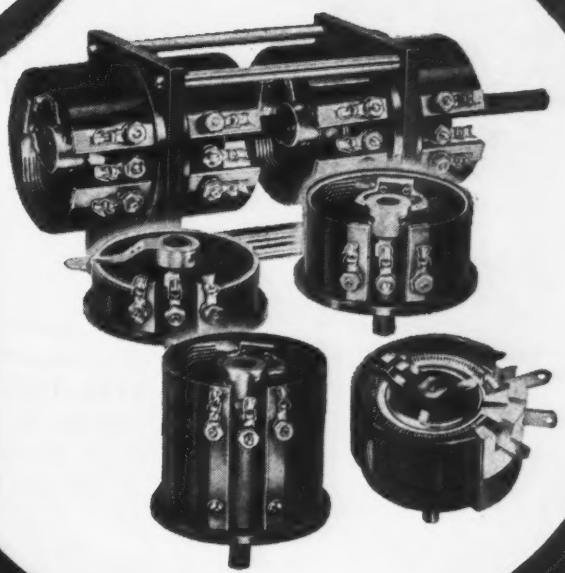


DeJUR ELECTRICAL INSTRUMENTS

Conservation of space and materials while, at the same time, maintaining efficiency is demonstrated in the DeJur 1½-inch Model 112 Meter. Four of these meters, as shown in the photograph, take no more room than one DeJur 3½-inch Model 312 Meter. Yet, the 112, measuring only 1¾ inches square and 25/32-inch deep is capable of doing a man-sized job in many applications where space is at a premium. Using basically the same carefully designed components as our larger instruments, this meter is built with fine watch precision. Available in standard ranges.

DeJUR RHEOSTAT-POTENTIOMETERS

The manufacturing scope of DeJur is exhibited in the wide range of our rheostat-potentiometer line. There are models for electronic devices, radio transmitters, dynamic voltage control, portable power amplifiers, mixing panels, spot welding, motor control, etc. Mechanically and electrically engineered to the precise requirements of the industry. Available in standard, multiple or ganged units, and units with special resistance values and tolerances. Designed for efficient service under all operating conditions.



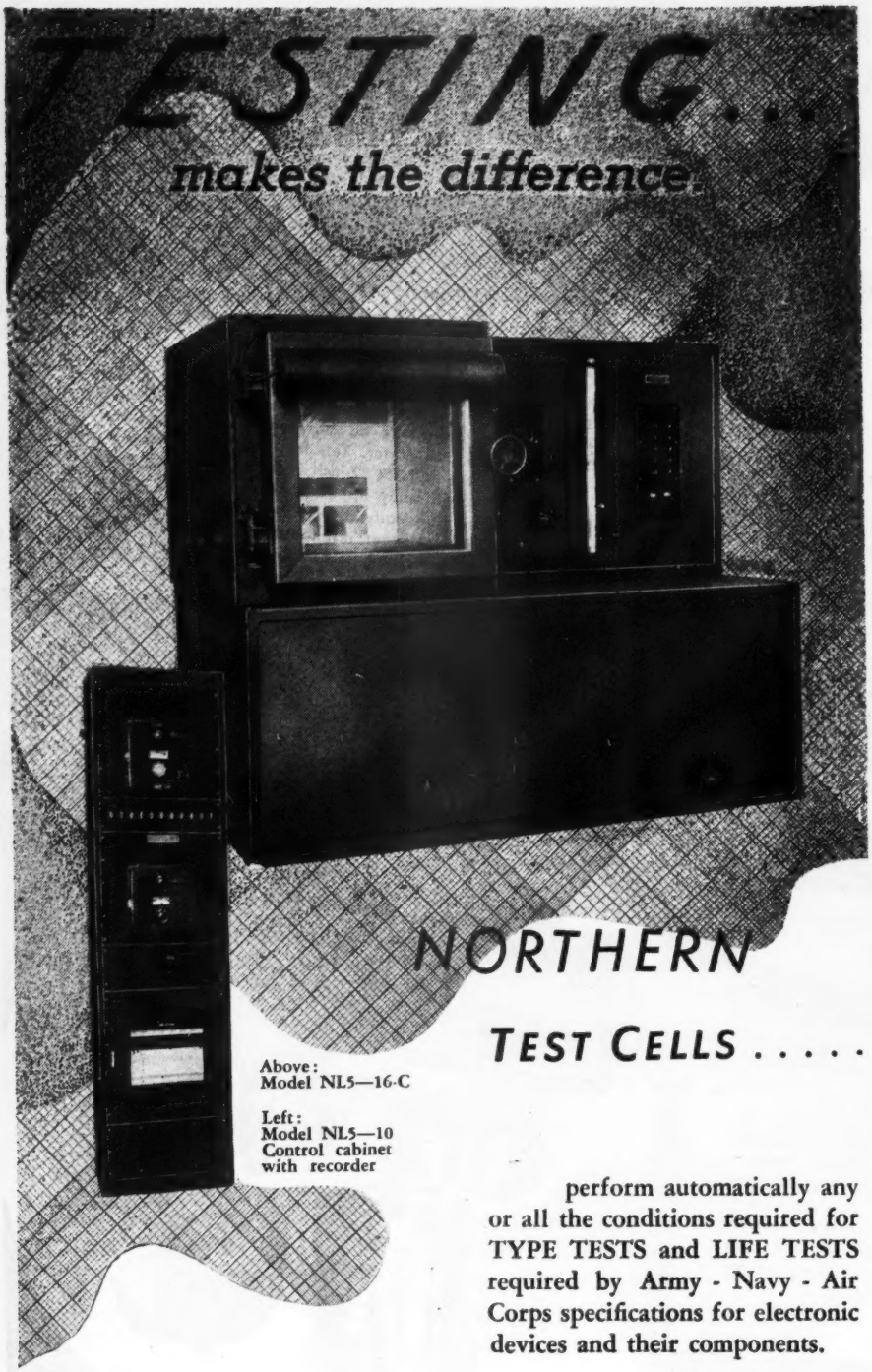
We are equipped to work with you on special models, of all DeJur products, for present or postwar applications. Write for the latest DeJur catalog.

ARMY E NAVY

BUY • AND • HOLD • MORE • WAR • BONDS

DeJur-Amsco Corporation

GENERAL OFFICE: NORTHERN BLVD. AT 45th ST., LONG ISLAND CITY 1, N. Y.



NORTHERN

TEST CELLS . . . . .

Above:
Model NL5—16-C

Left:
Model NL5—10
Control cabinet
with recorder

perform automatically any or all the conditions required for TYPE TESTS and LIFE TESTS required by Army - Navy - Air Corps specifications for electronic devices and their components.

Standard models may serve your purpose, but if your requirements are special remember that we are primarily custom builders of:

LOW TEMPERATURE—HIGH ALTITUDE—HUMIDITY test and calibration equipment for laboratory or production line.

Our Field engineers will be glad to call on you to discuss your problem.

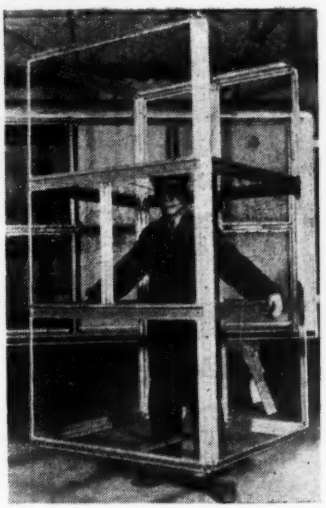
NORTHERN LABORATORIES LTD.

3-01 27th Ave., Long Island City, New York

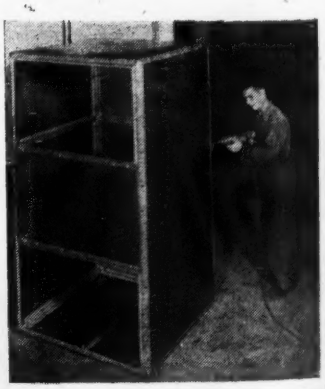
Aluminum Structure

LINDSAY STRUCTURES are now available in aluminum as well as in steel. The aluminum structures give a 50 to 60-percent saving in weight over the light steel structures, yet possess the same strength-weight ratio and ease of assembly features. These structures may be used as cabinets for electronic equipment and provide an all-metal shield that is rigid and free from vibration. The manufacturer states that because of its strength-weight ratio, the light-weight structure has adequate strength to support equipment installations. All parts for structure are accurately die-formed and can be quickly assembled with standard tools.

Lindsay & Lindsay, 222 West Adams St., Chicago, Ill.



The framework for this aluminum Lindsay structure cabinet is light enough to be easily handled by one man



Lindsay structure shell, approximately 76 x 42 x 39 in., weighs 128½ lb.

HOLD ON BOYS! WE SAID ALBION HAD PLENTY OF COILS—NOT GOILS!

SUPER-QUALITY COILS AT REASONABLE PRICES

More and more every day, the industry is turning to Albion for fast, quality and quantity production of coils, chokes, and transformers. That's because here you benefit from the unbeatable combination of management "know how," skilled workmanship, streamlined facilities, and central location. Your requirements will be given prompt and thoughtful attention.

ALBION
COIL COMPANY
ALBION, ILLINOIS

R. F. AND TRANSMITTING COILS AND CHOKES;
I. F. TRANSFORMERS

ELECTRICITY FOR ANY JOB —ANYWHERE

★ ONAN ELECTRIC GENERATING PLANTS supply reliable, economical electric service for electronics applications as well as for scores of general uses.

Driven by Onan-built, 4-cycle gasoline engines, these power units are of single-unit, compact design and sturdy construction. Suitable for mobile, stationary or emergency service.

Model shown is from W2C series, 2 and 3-KW, 60-cycle, 115 volt; powered by water-cooled, 2-cylinder engine.

ELECTRIC PLANTS Onan
POWER AND LIGHT FOR EVERY NEED

"Models range from 350 to 35,000 watts. A.C. types from 115 to 660 volts; 50, 60, 180 cycles, single or three-phase; 400, 500, and 800 cycle, single phase; also special frequencies.

D.C. types range from 6 to 4000 volts.

Dual voltage types available.

Write for engineering assistance or detailed literature".

D. W. ONAN & SONS — 3260 Royalston Ave. Minneapolis 5, Minn.

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The Importance of
MICA
for National Defense
Radio equipment used in tanks contains tubes and condensers in which Mica insulation plays a vital part.
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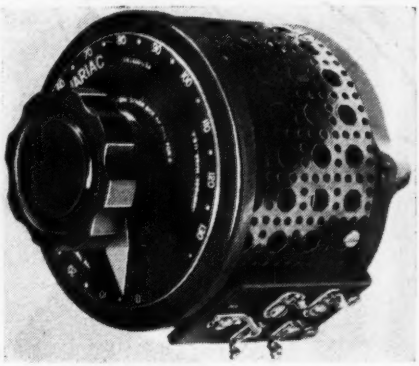
Established 1917 • Telephone: Windsor 9-8300

General Radio Devices

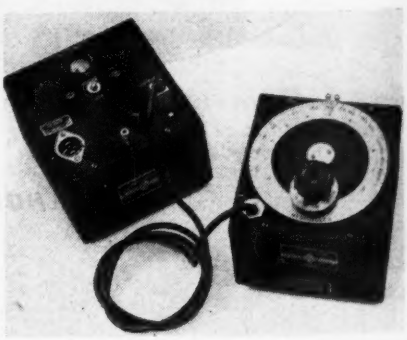
A VARIAC AND AN oscillator are two new instruments announced by General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.

Type 60-A is a 400-cycle Variac, 5-amp model for 115-v use. Rated nominally at 400 cycles, this variac can be used at any frequency between 400 and 2600 cycles. The rating is 860 v-amp. Output voltages



up to 135 v are obtainable with 115-v input. A new type of brush and radiator construction is used so that brushes can be changed in a few seconds. Type 60 Variac is available with or without a case. Overall height is 4⅛ in., overall diameter is 5½ in. Cased, the unit weighs 3½ lbs, and uncased 3 lbs, 2 oz.

Type 857-A u-h-f oscillator replaces the manufacturer's type 757-A. It is smaller and lighter



than the older type, covers a frequency range of 100 to 500 Mc, and is designed for use as a power source for laboratory measurements. Maximum output is ½ w or better over the entire frequency range. The frequency-determining element is a new type butterfly h-f tuned circuit in which the inductance and capacitance are varied simultaneously with a single control and no electrical contact to the

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Made-to-order at no extra cost

For the many years that sheet steel has been designated for spare parts boxes, Karp has been a major national supplier. Vast experiences, coupled with unusual production facilities, permit us to lay out and design boxes to *individual order* . . . at no extra cost. Each is built in accordance with U. S. Navy specifications. Tightly welded seams are vermin-proof. Special corrosion resisting paint is applied. Partitions, fittings, supports and trays are added as the case demands. Sizes range from 12" x 6" x 6" (and smaller where special existing conditions require) to boxes of sufficient length to house long motor shafts. *Rapid deliveries, too.*

Artisans in sheet metal, Karp craftsmen produce a varied line of products . . . from a chassis small enough to be handled by two fingers to a heavy rack which requires a crane to lift. We save you time, cost and manpower. A Karp engineer will gladly consult with you.

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CABINETS
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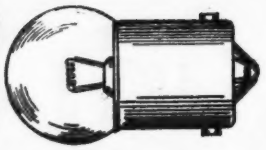
PANELS

HELP SHORTEN THE WAR . . . BUY MORE WAR BONDS

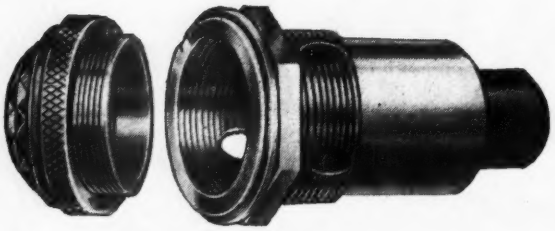
Specially recommended for heavy vibration



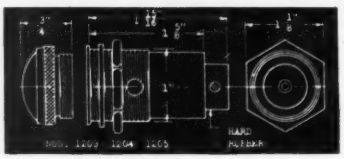
Gothard

No. 1203

PILOT LIGHT



Every design detail of this Gothard Light counteracts troublesome vibration. Jewel holder is threaded into body of light and is unscrewed to permit lamp change from front of panel. Bayonet type lamps are used—accommodating a range from 6 to 24 volt ratings. The No. 1203 requires only a 1" mounting hole and mounts on panels up to ⅜" thick. Metal parts are all brass, except hex nut. Heavy plated. Available with plain, faceted or frosted jewels—in colors: red, green, amber, blue, opal or clear as specified. Request your copy of the Gothard catalog for data on the complete line of Gothard Lights.



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Gothard MANUFACTURING COMPANY

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Export Division: 25 Warren Street, New York 7, N. Y. Cables—Simontrice, New York

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DELAY RELAYS

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3. Hermetically sealed — not affected by altitude, moisture or other climate changes . . . Explosion-proof.
4. Octal radio base for easy replacement.
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6. Circuits available: SPST Normally Open; SPST Normally Closed.

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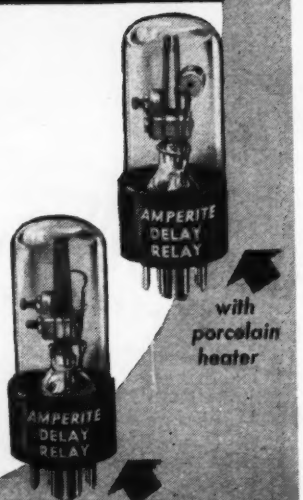


with porcelain heater

with heater wound directly on blade

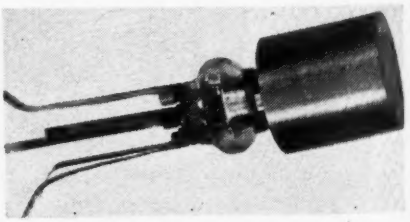
AMPERITE CO. 561 BROADWAY NEW YORK 12, N. Y.

In Canada: Atlas Radio Corp., Ltd. 560 King St. W., Toronto

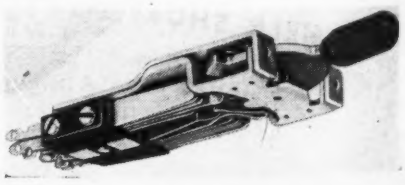
moving elements is necessary. Dial reads directly in frequency with an accuracy of ± 1 percent. Output is obtained at a coaxial jack at the side of the cabinet. Output coupling is inductive and can be varied continuously from maximum to practically zero. Supplied with the oscillator is Type 857-P1 power supply which furnishes filament and plate power and operates from a 115′ or 230-v a-c line, 42 to 60 cycles. A tube is used to indicate oscillation. Overall measurements of the oscillator are 6¼ x 7⅝ x 7¼ in. and it weighs 6¼ lb. The power supply unit measures 5½ x 6⅝ x 7⅝ in. and weighs 9½ lb.

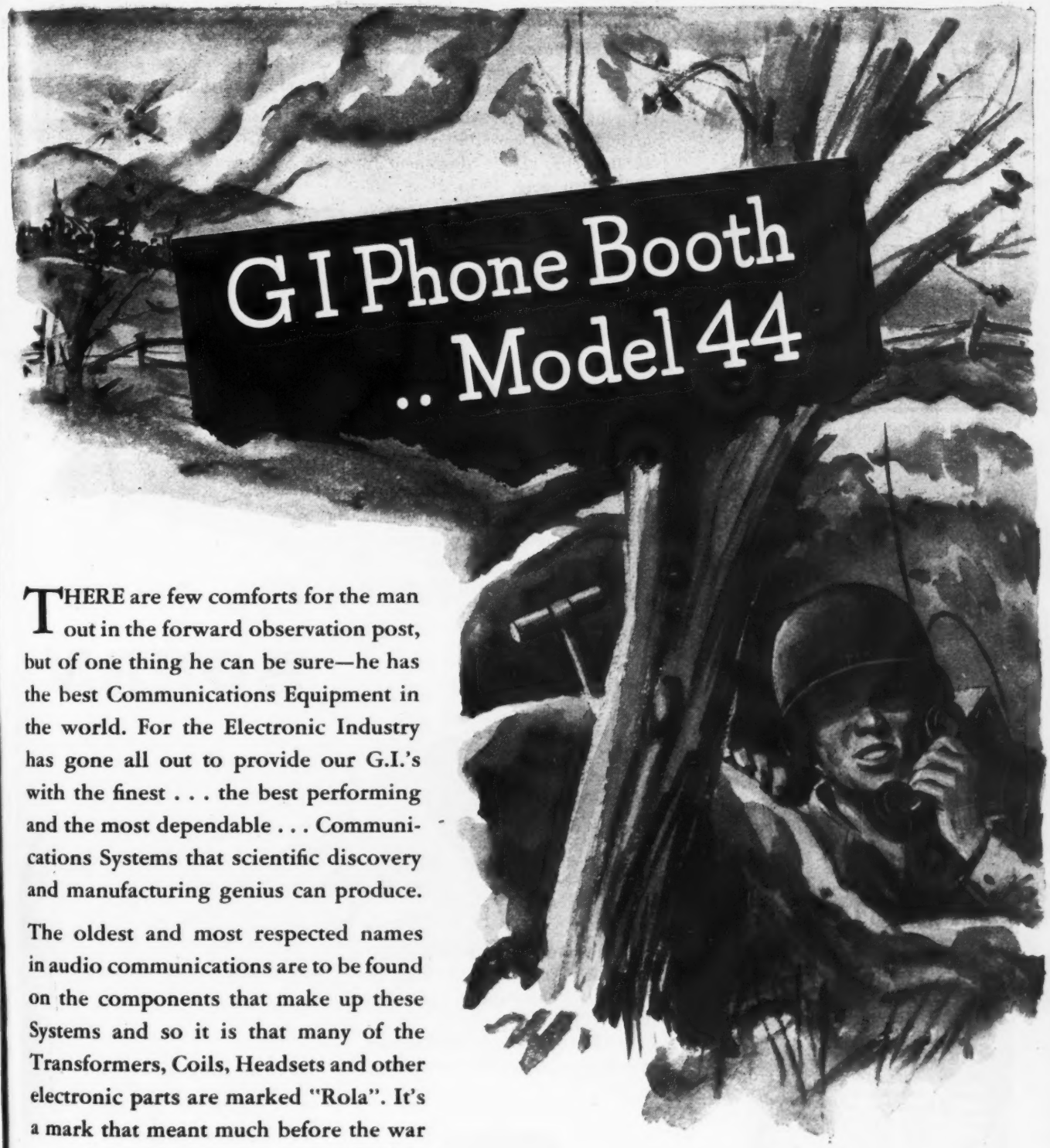
Federal Telephone & Radio Products

TYPE F-5303 IS an industrial power tube rated at 3.5 kw. Especially developed for industrial use in electronic heating, it is sturdy and compact and its six-inch flexible copper leads are permanently secured to the tube terminals. Filament and grid elements are conservatively spaced. No ceramic insulation is used. It is rated at 3500 w input and operates at full ratings at frequencies up to 50 Mc. Maximum ratings are: D-C plate voltage 3500 v, d-c plate current 1.0 amp, plate dissipation 1200 w. The filament current is 27.5 amp at 11 v. Overall height of the tube is approximately 7 in. and it has a maximum diameter of 3½ in. The tube is designed for forced-air cooling, but can be supplied for water cooling in Model No. F-5302.



The second new product announced by Federal is a narrow lever key (Series FTR-810) which





G I Phone Booth .. Model 44

THERE are few comforts for the man out in the forward observation post, but of one thing he can be sure—he has the best Communications Equipment in the world. For the Electronic Industry has gone all out to provide our G.I.'s with the finest . . . the best performing and the most dependable . . . Communications Systems that scientific discovery and manufacturing genius can produce.

The oldest and most respected names in audio communications are to be found on the components that make up these Systems and so it is that many of the Transformers, Coils, Headsets and other electronic parts are marked "Rola". It's a mark that meant much before the war . . . that will mean more in the Electronic Age now just beginning.

ROLA

THE ROLA COMPANY, INC.
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MAKERS OF THE FINEST IN SOUND REPRODUCING AND ELECTRONIC EQUIPMENT

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Radio and Electronic Components and Equipment
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HARVEY RADIO COMPANY
103 WEST 43rd ST., NEW YORK 18, N. Y.

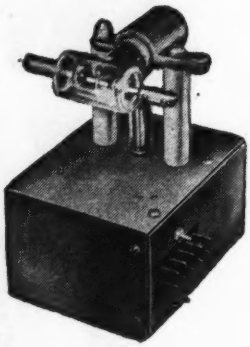
measures $\frac{7}{16}$ in. wide, and is for control purposes in electronic and communications equipment where small size is important. It has an 18-spring capacity which permits more than 500 possible switching combinations. It is designed for one or two way, locking or non-locking operation with a positive, snappy action. The key assembly is held together by a single screw.

Federal Telephone & Radio Corp. Newark 1, N. J.

Relays

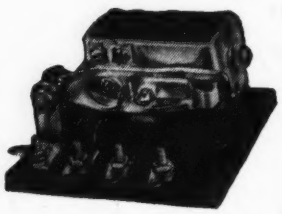
STRUTHERS-DUNN INC., (1321 Arch St., Philadelphia 7, Pa.) announce two products.

Type 78CCA100 vacuum switch keying relay weighs little, is sturdy, and has all parts readily accessible for inspection or adjustment. It has seven poles, including one dt



pole which handles high-voltage r-f currents by means of a vacuum switch. All high-voltage parts are rounded to reduce corona.

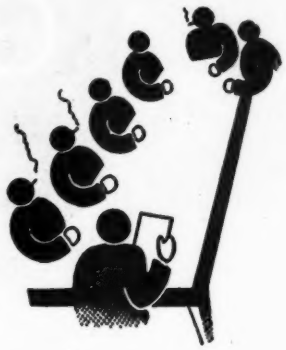
Type 79XAX is a redesigned snap-action relay for a wide variety



of applications. All parts are readily accessible and sensitivity adjustments can be made easily and quickly. Erratic operation due to slowly-changing coil-flux balancing the armature spring tension is eliminated. The armature of the

Make Plans Now . . .
for the coming . . .

PLASTIC ERA



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Whether your peacetime products are to include electronic equipment, electrical appliances, stoves or what have you, the Rogan Organization will gladly provide cost-free advice on all phases of plastic production.

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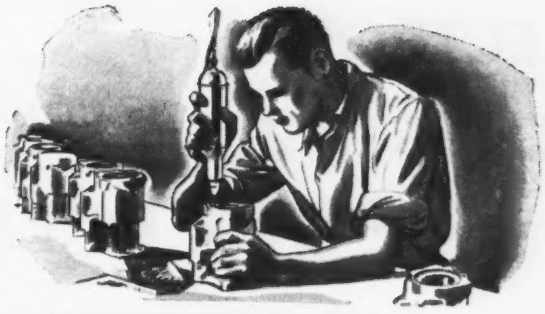
IT'S A PRODUCTION PLUSSER!

Time was when this manufacturer of magneto housings used slotted screws *and* helical inserts to fasten heads to withstand flight vibrations. Though expensive, this laborious, 2-step hand operation never produced completely vibrationless fastenings.



IT'S A COST REDUCER!

By switching to Phillips Recessed Head Screws, this manufacturer turned a slow-motion process into a fast, 1-step power operation, got a truly vibration-proof fastening. He also sliced fastening material costs about 71%, assembly costs correspondingly!

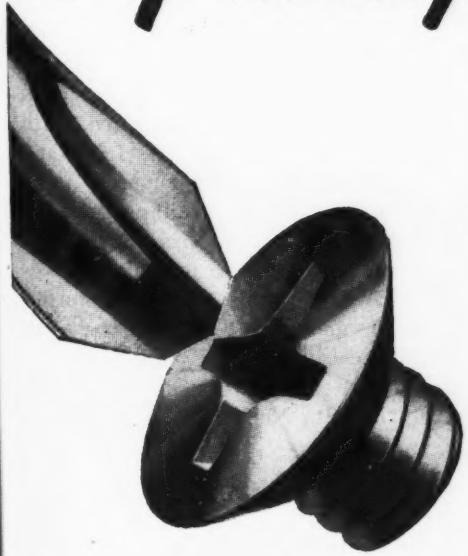
IT'S A STRENGTH BUILDER!

Besides being more efficient from assembly and cost angles, Phillips Screws are better from the design angle. Engineered to stand heaviest driving pressures, they take *any* load you need to impart product strength and rigidity.

IT'S AN ORDER GETTER!

From the sales angle, too, Phillips Screws are in a class by themselves. They snap up appearance of any product . . . make it stronger . . . and banish the burred screw heads that mar smooth surfaces, snag clothing, sabotage sales.

It's Phillips — the engineered recess!



In the Phillips Recess, mechanical principles are so correctly applied that every angle, plane, and dimension contributes fully to screw-driving efficiency.

. . . It's the exact pitch of the angles that eliminates driver skids.

. . . It's the engineered design of the 16 planes that makes it easy to apply full turning power – without reaming.

. . . It's the "just-right" depth of recess that enables Phillips Screw Heads to take heaviest driving pressures.

With such precise engineering, is it any wonder that Phillips Screws speed driving as much as 50% – cut costs correspondingly?

To give workers a chance to do their best, give them faster, easier-driving Phillips Recessed Head Screws. Plan Phillips Screws into your product now.

PHILLIPS *Recessed Head* SCREWS

WOOD SCREWS • MACHINE SCREWS • SELF-TAPPING SCREWS • STOVE BOLTS

Made in all sizes, types and head styles

24 SOURCES

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Continental Screw Co., New Bedford, Mass.
The Corbin Screw Corp., New Britain, Conn.
General Screw Mfg. Co., Chicago, Ill.
The H. M. Harper Co., Chicago, Ill.
International Screw Co., Detroit, Mich.
The Lamson & Sessions Co., Cleveland, Ohio
Manufacturers Screw Products, Chicago, Ill.
Milford Rivet and Machine Co., Milford, Conn.
The National Screw & Mfg. Co., Cleveland, Ohio
New England Screw Co., Keene, N. H.
Parker-Kalon Corp., New York, N. Y.
Pawtucket Screw Co., Pawtucket, R. I.
Pheoll Manufacturing Co., Chicago, Ill.
Reading Screw Co., Norristown, Pa.
Russell Burdsall & Ward Bolt & Nut Co., Port Chester, N. Y.
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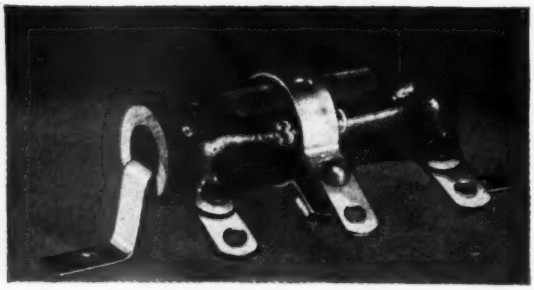
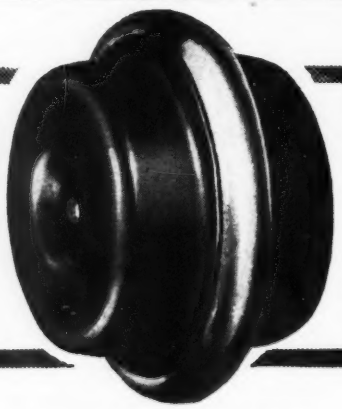
Lectrohm adjustable Resistors are a precision product. Resistance wire is silver soldered to the solder lugs by special process, assuring perfect electrical bond always. A thoro vitreous enamel coating completely embeds the accurately spaced winding, terminals and silver soldered connections — producing a solid, integral unit. These Resistors are used as voltage dividers, or potentiometers and can be equipped with several adjustable bands. Capacities 10 watt to 200 watt. Request complete information.



LECTROHM
INCORPORATED

5127 West 25th Street
Cicero 50, Illinois

G-E SAFETY SPARK GAPS



G-E Safety Spark Gaps are used for protection of condensers and other equipment against high-voltage surges. These spark gaps are of the metal-to-glass sealed gas-filled type. They are designed to perform satisfactorily over a wide range of temperatures. G-E Spark Gap ratings are 1200- and 2200-volts ±10%. They're available with or without mounting brackets.

Perhaps you have an application for G-E Safety Spark Gaps. For additional information write to Section Q256-119, Appliance and Merchandise Department, General Electric Company, Bridgeport, Connecticut.

BUY WAR BONDS AND KEEP THEM

Hear the General Electric radio programs: "The G-E All Girl Orchestra" Sunday 10 P.M. EWT, NBC. "The World Today" news every weekday 6:45 P.M. EWT, CBS.

GENERAL ELECTRIC

relay almost completes its travel in either direction before the contacts snap into the new position. A bulletin describing this relay more thoroughly is available.

Comparison Bridge

THIS COMPARISON bridge measures resistors, capacitors and inductors by comparison with a standard. Components can be measured with a precision ranging from 0.5 percent to 10 percent. This range can be extended to 20 percent. This unit is self-contained, and is a-c operated on 105 to 125 v, 50 to 60 cps. The instrument consists of one a-c bridge phase shift oscillator and a vacuum-type voltmeter. A null indicator in conjunction with a

calibrated dial indicates the percentage difference between the unknown and the standard. The comparison bridge is supplied with three frequencies of 60, 1,000 and 10,000 cycles. Components being compared to a similar standard range are: capacitors 25 $\mu\mu$f to 20 μf; inductors 5 microhenries to 500 henries, resistors from 10 ohms to 5 megohms. The instrument measures 10 x 7½ x 8¼ in.

Freed Transformer Co., 72 Spring St., New York, N. Y.

Transmitting Tube

TYPE 813 BEAM POWER transmitting tubes of high sensitivity are being manufactured by Taylor Tubes, Inc., 2312 Wabansia Ave., Chicago, Ill., under an RCA license. The tube has a maximum plate dissipation of 110 w. Maximum CW output is 360

U.S. Rubber Mountings are still War Materiel...

Nothing would please us more than to work with you on problems of eliminating vibration in post war equipment. But until the date of final supremacy for American arms is clearly at hand, commercial and domestic requests for U. S. Rubber Mountings must be subordinated to those directly involved in the war effort.

Right now, United States Rubber Company technicians are completely occupied with demands from the Army, Navy and Air Forces. New weapons—as well as new implements for communication and control—call for scientific protection against vibration and shock. And the proving-ground of mechanized warfare has shown that such protection is best provided by the use of rubber insulators.

Moreover, in plants directly concerned with turning out this materiel, engineered rubber mountings are no less essential. They help speed production; lengthen the life of critical machines.

You will find, however, when we are again free to serve you that "the new science of smoothness" has progressed enormously in recent years and months. War has taught our engineers and chemists much about rubber—the greatest and most useful of all the plastics.

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Consult our Design and Engineering Staff on your Special Problems in all types of Electronic Components.

Our Special Service Department has helped relieve many urgent production problems in organizations needing prompt deliveries. We are now able to extend these facilities to a few more accounts requiring limited quantities on Special Orders for Precision Electronic Parts.

w and plate modulated output is 240 w, when operated in Class C. Mounting is either vertical or horizontal (although when mounted horizontally the filament must be kept in a vertical plane.) Filament voltage is rated 10-v a-c, or d-c at 5 amp; transconductance for plate current of 50 milliamp is approximately 3750 μmhos; interelectrode capacitances, grid to plate (with external shield) 0.2 μmf maximum; input 16.2 μmf; output 14 μmf. The tube is available for military and government orders on priority basis for war contracts.

Aircraft Power Rheostats

THESE NEW UNITS, made in accordance with latest Army-Navy Aeronautical Specification AN-R14a, are light in weight, meet various critical tests, and operate satisfactorily in temperatures from —55 deg C to +70 deg C. The two types available include Model J which is

rated 50 w, and Model H rated at 25 w. They are supplied with either linear or tapered windings in various resistances, with "off" position, as required. The units are enclosed in compact, corrosion-resisting metal containers and come supplied with a knob as illustrated.

Ohmite Mfg. Co., 4835 Flournoy St., Chicago 44, Ill.

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NEW

"ELINCO" A.C DRAG-CUP INDUCTION GENERATORS

Both base and frame-mounted models, die-cast aluminum-alloy housing, black enamel finish. Torque required for rotation approximately 25 grains at 1" rad. *Type 68:* applied voltage (to one of the two stator phase terminals) 115 v.a.c., generated voltage (at other terminal) with resistive load 100,000 ohms varies from 0.15 v. max. with drag cup stationary, to 1.20 v. min. at 1,000 RPM, and to increase at uniform rate up to 6,000 RPM.

OTHER MODELS

The business of our company is the design and production of special fractional h.p. motors and generators to meet the requirements of individual customers. We will be pleased to assist in the solution of your problems.

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THE production of high-efficiency electrical and electronic equipment demands close control over the manufacture of most of the parts which go into it.

To be certain of accurate control over component parts, Connecticut Telephone and Electric Division manufactures an unusually high percentage of them in its own plant. For instance, we produce our own magnets, wind our own coils. Stampings and screw machine products are turned out to our own standards, in our own shops.

These facilities for complete fabrication of the more essential elements of a piece of electrical or electronic equipment are as important to our customers as to us—they result in a better product at a "better" price . . . also assurance of our ability to keep delivery promises.

MAGNETS have a great deal to do with the efficiency of many types of electrical apparatus. Specially developed alloys treated in our own electric furnaces permit close control over the performance of C. T. & E. products.

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We look upon our 2nd Award as a renewed challenge, saying: "Back up our fighting men . . . Give them the material strength with which to implement their fighting hearts!"
We shall answer this call with new records of exceptional performance worthy of the trust placed in us by the Armed Forces.
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HEADQUARTERS FOR RADIO-ELECTRONIC PRODUCTS
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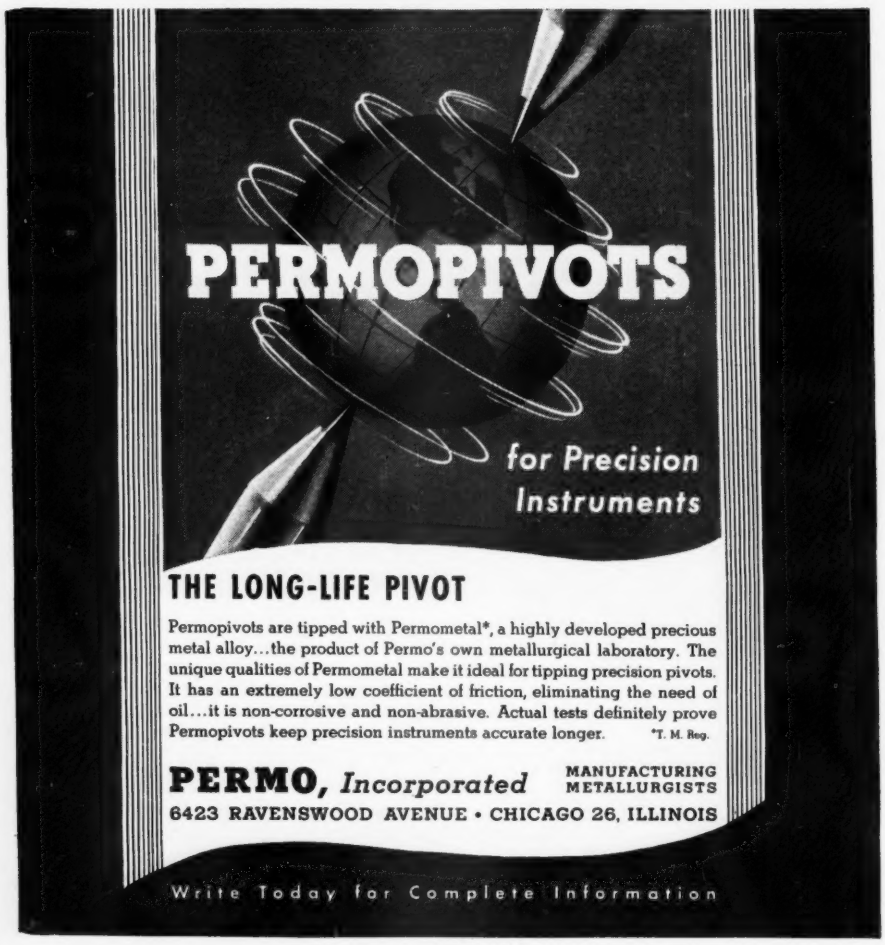
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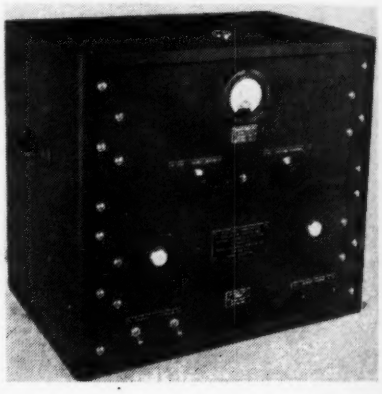
Write Today for Complete Information

Regulated Power Supplies

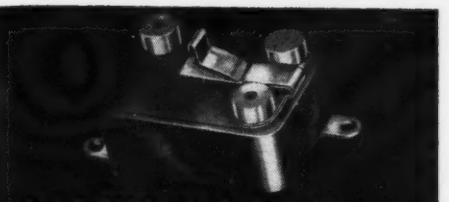
IN APRIL ELECTRONICS Model 44 power supply unit is described. The manufacturer now has available Model 44-B (illustrated) which is similar to Model 44, but provides higher load current. Output current is rated 250 milliamp maximum (Model 44 is rated 100 milliamp maximum). Other characteristics for both models are: input 105-125-v a-c; output voltage 0-300 v d-c in three ranges; regulation (maximum voltage change with load) ±0.2 v at 300 v; ±0.1 v on 0-10-v range. Line stability (maximum voltage variation with line changes) ±0.5 v at 300 v; ±0.15 v on 0-10-v range. Both instruments are intended as general laboratory instruments, or wherever a source of voltage of a variable nature is desired. A 4-page bulletin describing these units, as well as Model 42-A (described in May ELECTRONICS) is available from the manufacturer, Radio-Television Institute, Inc., 480 Lexington Ave., New York 17, N. Y.



Insulated Carbon Resistors

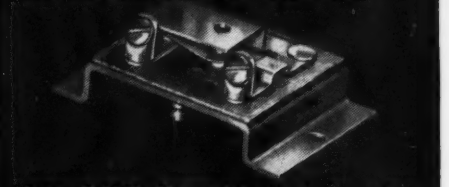
TWO NEW LINES, consisting of five different types of insulated carbon resistors (which cover six different AWS ratings: RC10, 20, 21, 30, 31 and 40) are in production by Erie Resistor Corp., Erie, Pa.

The first line consists of Erie type 504B (RC21) which measures $\frac{9}{16}$ in. in length, and $\frac{3}{32}$ in. in diameter, and which replaces the manufacturer's type 504. Type 518B (RC31) replaces type 518. It measures $\frac{33}{32}$ in. in length and $\frac{13}{64}$ in. in diameter. The newer types have one-piece molded phenolic cases in-



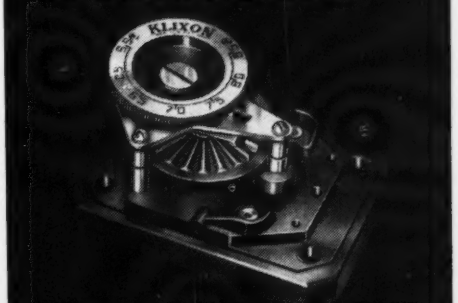
Type C-7220 Precision Snap Switch
12 amps. 30 Volts D. C., 125 Volts A. C.

Type C-2851 Thermostat. For such use as Roughing Controls on Outer Crystal Ovens

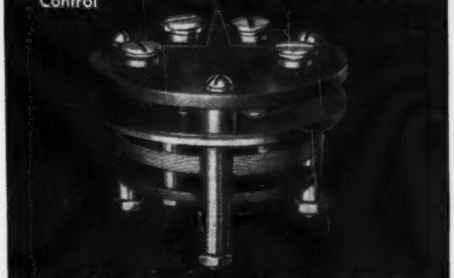


Type C-4351 Thermostat. Used for Tube Warming, Tube Cooling, High Limit Controls, etc.

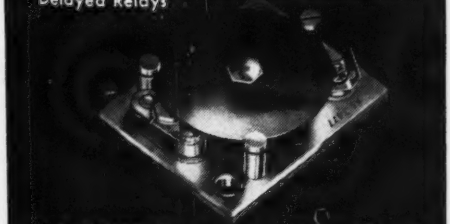
Type PM (NAF-1131) Circuit Breaker



Type RT Thermostat. Adjustable Temperature Control



Type ER Series. Ambient Compensated Time Delayed Relays



Type B-3120 Thermostat and Heater, Crystal Dew Point Control

P Q 'S AND 'S

of Reliable Control or Protection...

- • -

KLIXON DISC-OPERATED CONTROLS

Simplicity of operation is the reason for the accurate operation of Klixon Controls. These compact, light-weight controls are actuated by a simple scientifically calibrated Spencer thermostatic disc. This foolproof actuating element does away with complicated relays, toggles, magnets and other fussy parts that tend to wear and get out of adjustment. It provides sure operation by snapping to a quick clean break or a solid make . . . no matter how often it operates. And because there's nothing to get out of order, its accurate performance is unaffected by motion, altitude, vibration or shock regardless of the position of mounting.

Klixon Controls are available in a wide range of types and sizes for such applications as motor and transformer overheat protection, electric circuit overload protection, thermal time delays or temperature control for radio equipment. Investigate Klixon Controls for reliable control or protection applications. Complete information sent on request.

KLIXON

SPENCER THERMOSTAT COMPANY, Attleboro, Mass.

3½ ounces

WITH TWELVE CONTACTS

GENERAL CONTROL COMPANY'S NEW MODEL MCM "MIDGET"

LEVER SWITCH

The "Midget" is designed especially for electronic and communications circuits in aircraft, and for other light duty applications. It is a "Midget" in both size and weight . . . it saves precious space and weight, yet is so ruggedly constructed that it will stand severe use.

The contact possibilities are unlimited . . . contact assemblies can be removed from the frame by removing a single bolt . . . all parts are non-corrosive . . . has easy, positive roller action, regardless of number or arrangement of contacts on each side of the switch . . . a single hole only is required for panel mounting . . . a key can be provided to prevent turning in the mounting panel . . . rated from 5 to 10 amperes, 125 volts A.C.

The standard "Midget" has either three positions as shown in illustration, or can be supplied with two positions (no neutral).

GENERAL CONTROL COMPANY

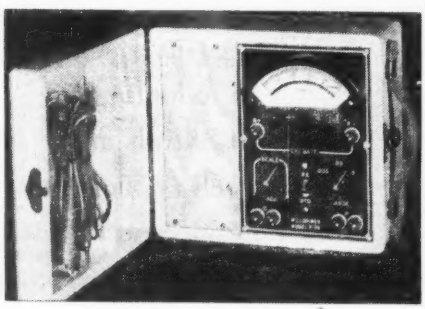
1202 SOLDIERS FIELD ROAD
BOSTON 34, MASS.

stead of ceramic insulation, and are available in resistance values from 0.5 ohm to 100 megohms.

Other units announced include a new line of compact, hot molded, insulated resistors in ¼-, ½-, 1- and 2-w ratings in the following types: Type 524 (RC10 and RC20) measures ⅜ in. in length, 0.135 in. diameter; Type 525 (RC30) measures ⅝ in. in length and ⅞₂ in. diameter; and Type 526 (RC40) measures 1⅜ in. in length, and ⅜ in. diameter. The resistance mix and insulation material of these types are molded simultaneously as an integral unit. The resistors are manufactured only in RMA preferred values from 220 ohms up to and including 4.7 megohms. Wire leads are 1½ in. maximum, No. 20 wire on types 524, 504B and 518B; No. 18 wire is used on types 525 and 526.

Resistance Meter

MODEL P-25 Milliohmer may be used in bond testing, or to measure switch or contact resistance, or fractional ohm standards, or in quantitative analysis (by the resistance check method). The circuit of the instrument is an adaptation of the potentiometric method of low resistance measurement. Accuracy is rated 1 percent or better. The meter has three ranges—from zero

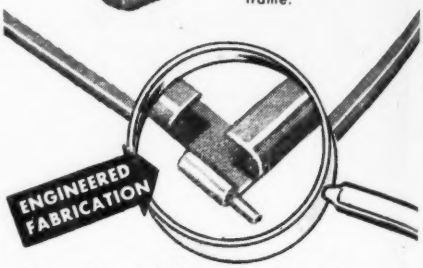


to 0.005, 0.05 and 5 ohms. The scale is a direct-reading linear type. It is mirrored to eliminate parallax and facilitate extremely accurate readings. Built-in standard resistors are all of the 4-terminal type and are individually adjusted to an accuracy of ½ of 1 per cent. The unit operates on self-contained batteries. Available on priority of AA3 or better.

Superior Instruments Co., Dept. U, 227 Fulton St., New York 7, N. Y.

Specializing in those TOUGH metal parts fabrications and assemblies

"Unusual assembly requirements have been met—simply and satisfactorily — through resourceful fabrication techniques in the production of this metal chart frame."



Complex fabrications, involving unusual structural and mechanical features, can be produced by OLYMPIC with accuracy and precision. Complete design collaboration from blueprint to production, will result in greater product efficiency.

Whether your future product involves production tooling, forming, drawing, stamping, welding, brazing or soldering, OLYMPIC will satisfactorily meet your requirements. Remember the name—OLYMPIC—for the tough jobs.

CRAFTSMANSHIP IN METAL PARTS

OLYMPIC TOOL & MFG. CO., INC.
39 CHAMBERS ST.
NEW YORK 7, N. Y.

UNTIL the armed forces of the United Nations get all of the FERRANTI Products they need, civilian requirements must rate second place!

But our capacity is now more than ten times what it was a few years ago—and is still increasing.

We are therefore in a position to offer prompt delivery schedules on most products—exceptionally prompt delivery on many items—plus many worthwhile improvements growing out of our own wartime engineering program.

● WE THEREFORE SUGGEST:

Before making your commitments—find out what FERRANTI can do.
Full Facilities for Wiring and Assembly of Complete Equipments

FERRANTI ELECTRIC, INC., R. C. A. BLDG., NEW YORK 20, N. Y.

TRANSFORMERS • REACTORS • FILTERS • EQUALIZERS • ATTENUATORS • RECTIFIERS • PLATE-FILAMENT • ELECTROSTATIC VOLTMETERS • WIRING AND ASSEMBLY • MODULATION SETS • AERO TRANSFORMERS

PROMPT—SERVICE—DELIVERY

FERRANTI

HEXACON
is helping to do the job at
SPERRY

HATCHET TYPE IRON
for better balance and
less operator fatigue

(PATENT PENDING)

Offering even greater ease in handling than the light-weight irons now used for difficult, intricate soldering, the Hatchet Type iron is especially engineered and designed for operator comfort. Non-tiring even after hours of continuous use, these soldering units have all the extra advantages included in every HEXACON iron — replaceable elements of highest grade nickel-chromium wire, tips of hard-drawn copper, hexagon-shaped barrels for maximum heat dissipation during intermittent use, Underwriters' Laboratories approval, etc.

WRITE FOR ILLUSTRATED BULLETINS
The complete diversified range of HEXACON soldering irons is described in detail in fully-illustrated literature. Ranging from 40 to 700 watts, and with tip diameters ¼" to 1¾", HEXACON irons are available to meet every requirement. Write today—there is no obligation.

HEXACON ELECTRIC CO.
130 W. Clay Ave.. Roselle Park, N. J.

HIGH-QUALITY
LONG-LASTING
SOLDERING IRONS

HEXACON

Another DX FIRST!

For more than a year DX Crystals have been automatically deep-etched by a new process. Both the method and machines were perfected by DX Engineers so that all DX Xtals can have the nth degree of stability and endurance necessary to wartime operation.

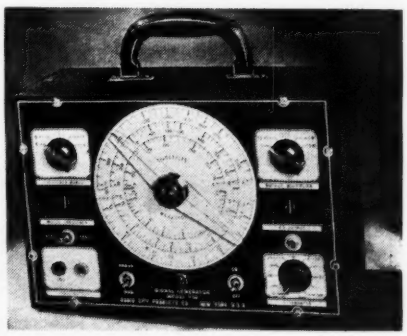
Think about DX Products for your new receivers and transmitters.

DX CRYSTAL CO.
GENERAL OFFICES 1200 N. CLAREMONT AVE. CHICAGO 22, ILL. U. S. A.

DX XTALS
the heart of a good transmitter

Signal Generator

SIGNAL GENERATOR, Model No. 704, is a complete wide-range testing instrument with a range from 95 kc to 100 Mc. Fundamental frequencies are continuously variable from 95 kc to 25 Mc in 5 bands. Calibration is accurate to 2 percent per band up to the broadcast band, and within 3 percent for high frequency bands. A planetary drive capacitor with direct-reading calibration is used. Output can be modulated or unmodulated. Self-contained carrier-modulation is



either 400 cycles or 1,000 cycles, sine wave. Either is available for external use. Protective features of the instrument include automatic shorting of all coils not in use; individual shielding of r-f circuits, coil assembly and attenuator; and an overall steel case, chassis and panel. A 5-step attenuator is used for controlling the output. The instrument is supplied with a pilot-light "on-off" indicator and a double-fused cord.

Radio City Products Co., 127 West 26th St., New York 1, N. Y.

Current-Measuring Instruments

THESE CURRENT-MEASURING instruments feature linear scales, unit construction and dust-proof cases. Unit construction means that the jewel bearings, armature and core are all assembled as a unit and that the Alnico magnet and pole pieces are brazed together as a unit. Brazing is done in an induction furnace to insure a uniform joint and to prevent spreading or loosening under vibration. Standard meters come in a wide range of models. The manufacturer will design meters to

SYLVANIA NEWS

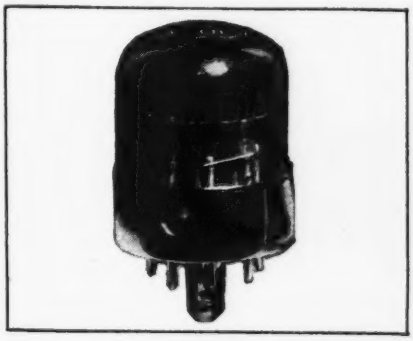
ELECTRONIC EQUIPMENT EDITION

FEBRUARY *Published in the Interests of Better Sight and Sound* 1945

Type 1AB5 Used as Mixer, RF Amplifier At 50Mc. and Above

Sylvania Electric's 1AB5 tube is a filament type pentode for use as a mixer or RF amplifier in circuits requiring a tube of greater mutual conductance than the 1LN5.

The 1AB5 is especially designed for operation at frequencies of 50Mc. and



higher. Its combination of characteristics results in higher effective input resistance at these frequencies.

The tube has an 8-pin base of the Lock-In type, and a Short T-9 bulb. It is designed to operate on a filament voltage of 1.2. Full technical data are available from Sylvania Electric.

DID YOU KNOW...

That new long, small diameter fluorescent lamps soon to be placed in production at Sylvania Electric will be of the instant starting type? Using no starters, they will need less maintenance.

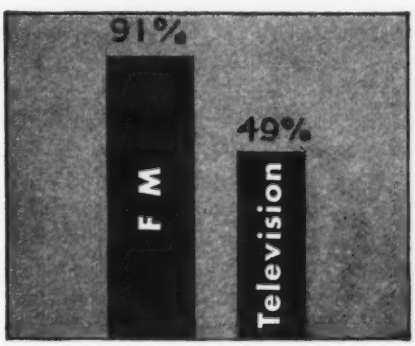
★ ★ ★

That the taking of tube characteristics by photographing an oscilloscopic trace permits the measurement of tube performance which could not otherwise be obtained? This is the method used in the Sylvania Laboratories.

Set-Owners Place FM First in Sylvania Survey of Radio Sets

91% of Consumers Interviewed Say They Want This Feature in Postwar Receivers

Preliminary reports of the nationwide survey being conducted by Sylvania Electric indicate a high degree of interest in frequency modulation. Of the thousands of set-owners who have been personally interviewed, 91% have indicated their desire to have FM incorporated in their postwar receivers. 70% said that they were willing to pay an additional sum in order to get this feature.



Graph shows percentages of set-owners stating that they want FM and television in their postwar sets.

"Would you be willing to go as high as $300 to have FM and television included in your radio set?"

Television, while also a subject of considerable interest, ranked behind FM in the tabulation of survey results. 49% of those interviewed stated that they wanted television reception after the war. The same percentage indicated their willingness to pay extra for it.

INFLUENCE OF COST

As a guide to set manufacturers in their postwar planning, the Sylvania survey is also eliciting information on the amounts which consumers would be willing to pay in order to have FM and television. The results of this phase of the survey will be published in subsequent issues of SYLVANIA NEWS.

SURVEY CONTINUES

While the analysis of the results of personal interviews is going on, Sylvania Electric is continuing its survey, and broadening its scope, through the medium of a series of questionnaire-type advertisements appearing in leading national magazines.

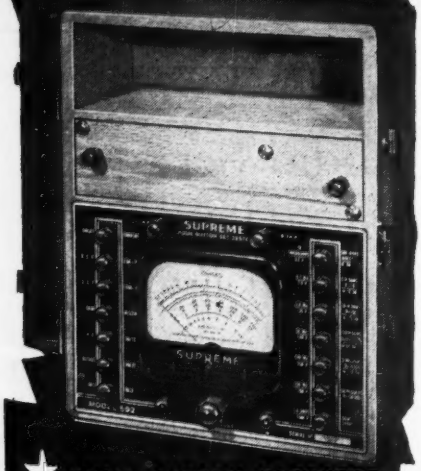
The purpose of these advertisements is to gather additional information on consumer preferences and interest, not only in various types of radio and television receivers, but also in the possibility of using electronic devices in their homes.

SYLVANIA ELECTRIC

SYLVANIA ELECTRIC PRODUCTS INC., *Radio Division*, Emporium, Pa.

MAKERS OF RADIO TUBES; CATHODE RAY TUBES; ELECTRONIC DEVICES; FLUORESCENT LAMPS, FIXTURES, ACCESSORIES; INCANDESCENT LAMPS

THE SPEED TESTER
SUPREME
MODEL 592
★ 25,000 OHMS PER VOLT



★ PUSH BUTTON OPERATED

★ Design proven by over 5 years production
★ Dual D.C. Sensitivity—25,000 ohms per volt and 1000 ohms per volt
★ Matched resistors of 1% accuracy
★ Push button operated—no roaming test leads
★ Open face—wide scale 4¼" meter. 40 microamperes sensitivity
★ 1 Microampere first scale division

SPECIFICATIONS

D.C. MICROAMPERES:
0-70-700 microamperes
D.C. MILLIAMMETER:
0-7-35-140-350 milliamperes
D.C. AMMETER
0-1.4-14 amperes
D.C. VOLTS, 25,000 OHMS PER VOLT:
0-3.5-7-35-140-350-700-1400 volts
D.C. VOLTS, 1000 OHMS PER VOLT:
0-3.5-7-35-140-350-700-1400 volts
A.C. VOLTS, 1000 OHMS PER VOLT:
0-7-35-140-350-700-1400 volts
OUTPUT VOLTMETER:
0-7-35-140-350-700-1400 volts
DECIBEL METER:
0 db to plus 46 db
OHMMETER:
0-500-5000-50 000-500,000 OHMS
0-5-50 MEGOHMS
POWER SUPPLY
Battery Operated

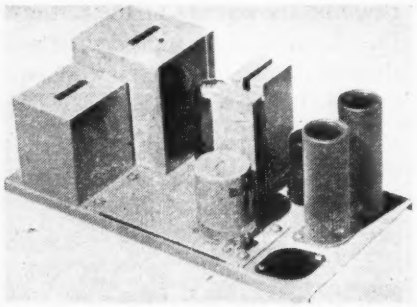
With the above specifications the Supreme Model 592 Speed Tester meets today's requirements for general laboratory use, assembly line tests and inspection, radio and other electronic repair and maintenance.

SUPREME
SUPREME INSTRUMENTS CORP.
Greenwood, Miss., U.S.A.

fit individual needs, if desired. A catalog sheet, No. 101, explains the functions, adaptability and construction of these meters which are available from General Electronics Mfg. Co., Culver City, Calif.

Amplifiers

FOR F-M APPLICATIONS Series 102 amplifiers with mounting accessories are available. The series consists of the following four types of amplifiers: Type 102-A which has input impedances of 30/250 ohms and output impedance of 600 ohms; frequency response of 30-16000 cps, ±0.5 db. Type 102-B is a three-stage amplifier with a gain of 95

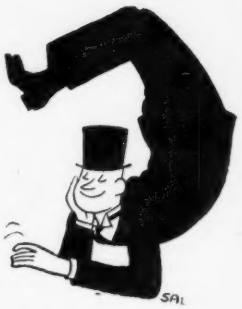


db. It employs input stage mixing, and is intended for public address installations. Type 102-C consists of a three-stage amplifier, fixed gain, adjustable, 75/85/95 db. Type 102-D is a two-stage amplifier with fixed gain of 61 db with 600 ohms input impedance, and 45 db bridging also with 600 ohms input impedance.

The Langevin Co., Inc., 37 West 65th St., New York 23, N. Y.

Electronic Control

DESIGNATED AS Type P25N is an electronic concentrate control for detecting and controlling, through operation of signals, valves or pumps, changes in liquid concentrations. It is intended for all applications in which changes in concentration are accompanied by a corresponding change in electrical conductivity. The instrument has a sensitivity range of 100 to 5,000 ohms and operates on a 5 percent change in probe-circuit resistance. The predetermined resistance value for which the control is set remains fixed regardless of va-



ADAPTABILITY
...used to doing the unusual

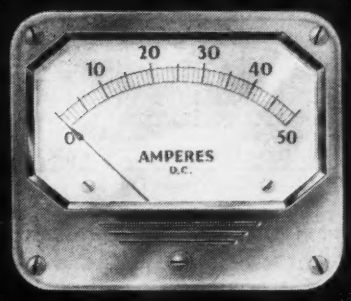
Does some part of the product you make present an unusual problem? You are under no obligation when you ask our consultant service for help. Our engineering thinking and our machines are both adapted to doing the unusual. And chances are that a cold-forged part will be more economical for you.

This Decimal Equivalents wall chart is accurate to four places and signalled in three colors. Yours at no cost or obligation. Just send us your name, title and address.

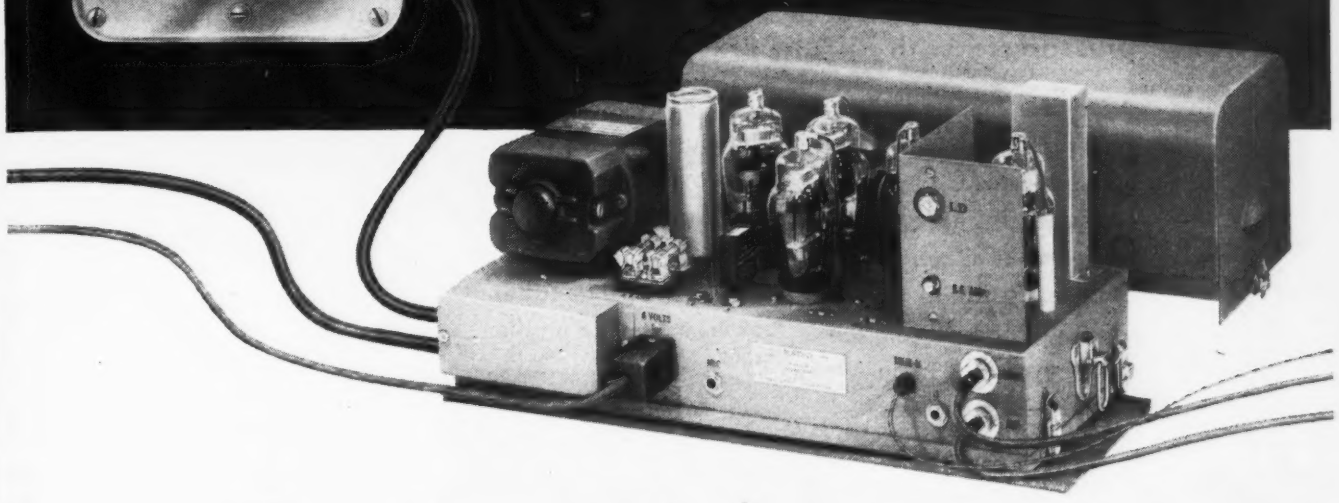
See our Catalog in Sweet's File for Product Designers

JOHN HASSALL INC.
Specialists in Cold-Forging Since 1850
150 Clay Street
Brooklyn 22, N.Y.

SPECIAL NAILS RIVETS SCREWS
Hassall



READY TO TRANSMIT
–yet standby current is zero!



To reduce drain on batteries specify
KAAR *Instant-Heating* RADIOTELEPHONES

One of the special features of Kaar mobile transmitters is their instant heating tubes. When the "push-to-talk" button on the microphone is pressed, the transmitter immediately goes on the air... but between transmissions standby current is zero. By eliminating battery drain during standby periods, this 22-watt transmitter can be operated from a vehicle's 6-volt ignition battery without requiring frequent re-charging.

The PTS-22X shown above operates on frequencies between 30 and 40 megacycles. (Available up to 62-MC on special order.) Two other Kaar transmitters, the PTL-10X and PTL-22X, for operation in the 1600-2900 KC band, are likewise equipped throughout with instant heating tubes.

Notice also how the dust cover can be removed by releasing two luggage type catches. Likewise the entire chassis can be removed for checking or servicing by releasing four additional catches.

These are but two of the features which make Kaar Radiotelephones so popular for military, civil and commercial communication between mobile units and a central station.

KAAR
ENGINEERING CO.
PALO ALTO, CALIFORNIA

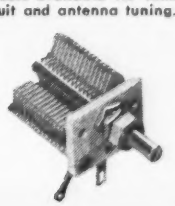
KAAR ENGINEERING CO.

Export Agents: FRAZAR & HANSEN
301 Clay St., San Francisco 11, Calif., U.S.A.

MOBILE RECEIVERS—Crystal controlled superheterodynes for medium and high frequencies. Easy to service.

CRYSTALS—Low-drift quartz plates. Fundamental and harmonic types available in various holders.

CONDENSERS—Many types of small variable air condensers available for tank circuit and antenna tuning.



MICROPHONES—Type 4-C single button carbon. Superb voice quality, high output, moisture proof.

POWER PACKS—Heavy duty vibrators and power supplies for transmitters, receivers. 6, 12, 32, volt DC.

IT'S DRY!

—and so is your equipment when it's been pressurized with an **ANDREW DRY AIR PUMP**

Type 876-A

● Dry Air Pumps provide simple, inexpensive source of dehydrated air for your pressurized electronic products. You can avoid component failure due to humidity by enclosing the entire apparatus in an air tight chamber and maintaining dry air pressure.

For air-borne equipment, too! Condenser plates will not spark over at high altitudes if the apparatus is pressurized with dry air, because then moisture condensation is no longer a problem.

FOR DETAILED INFORMATION WRITE FOR BULLETIN No. 30

ANDREW CO.
ANDREW
363 East 75th Street
Chicago 19, Illinois

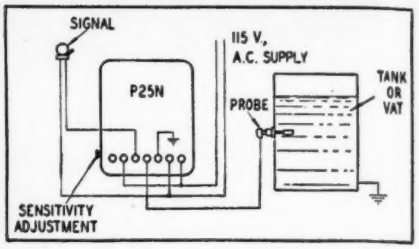
ZOPHAR

Fungus-Proofed Waxes

As a vital service to the Armed Forces we now offer Fungus Resistant Materials. These recently developed products are the answer to Communications requirements where the impregnation or coating of radio parts and equipment are concerned.

ZOPHAR waxes and compounds meet every specification of both the Army and Navy for waterproofing and insulating all electrical and radio components. They also have wide application in packaging of every description.

ZOPHAR MILLS INC
112-130—26th STREET
BROOKLYN, N.Y.
ESTABLISHED 1846



riations in line voltage or tube characteristics. The voltage applied to the probe does not exceed 25 v, which eliminates the possibility of electric shock or explosion hazard. The unit incorporates a sp, dt relay, rated at 10 amp a-c, 5 amp d-c, for normally closed and normally open operation, and requires a power supply of 115-v a-c 60 cycles.

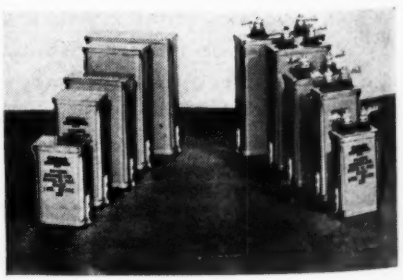
Photoswitch Inc., 77 Broadway, Cambridge 42, Mass.

Plugs and Jacks

FOR MANUFACTURERS of radio and radar parts and components, plugs and jacks (made to Signal Corps specifications) are available in the following types: JK-48, JK-26, JK-55 jacks, and PL-54, PL-55, PL-204, PL-291 and PL-291A plugs. These are manufactured by Amalgamated Radio Television Corporation located at 476 Broadway, New York, N. Y.

Capacitor Mounting

M TYPE BRACKETS (illustrated) have been specially developed to withstand severe vibrations, and meet all Army, Navy and Aircraft specifications. Although designed pri-



marily to permit mounting of oil capacitors in either vertical or inverted position, they are suitable for other industrial applications.

Industrial Condenser Corp., 3243 North California Ave., Chicago 18, Ill.

What's Back of LEAR RADIO

THE NAME "LEAR" on home radios is something new. But Lear has a long history of success in radio development.

This history dates back to 1930.

Lear thinking helped to make automobile radios possible. It was Lear inventive foresight that contributed to the success of many of the most famous radios on the prewar market.

But before the war, Lear preferred to produce aircraft radios—instruments for a service that was tough and exacting.

All through the war, Lear continued radio development.

Now this ability to foresee and create is being directed into fine radios for America's homes. They will be radios such as you and your customers have never known before.

This will make the Lear distributor franchise a particularly valuable one. But there is even more! Lear policy is aimed to protect Lear distributors and dealers.

Stable discounts on stable prices on stable models will provide the sound basis for a long, steady, successful business.

You'll be interested in knowing more about selling Lear home radios. We'll be glad to tell you about it. Address LEAR, Incorporated, Home Radio Division, Sales, 230 East Ohio Street, Chicago 11, Illinois.

LEAR RADIO

Lear INCORPORATED

SERVICE THROUGH THE YEARS! 1945

★

America's MOST COMPLETE Source of Supply for

RADIO PARTS
RADIO TUBES
INDUSTRIAL ELECTRONIC EQUIPMENT
AMPLIFIERS
SOUND SYSTEMS
TEST INSTRUMENTS
COMMUNICATIONS and BROADCAST APPARATUS
AIRCRAFT and MARINE EQUIPMENT
F/M—television—A/M

★

OVER 10,000 ITEMS AT YOUR FINGERTIPS!

PURCHASING AGENTS! ENGINEERS!
Send for this
FREE 800 PAGE CATALOG!

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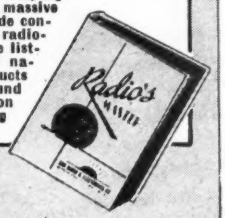

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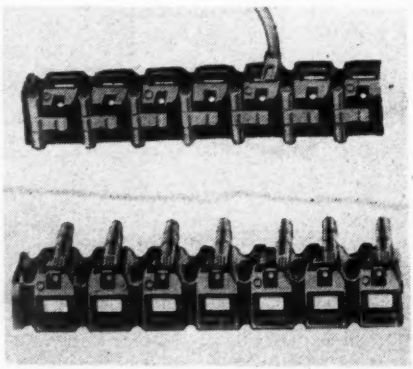

fastening device is necessary. The block may be used in place of disconnect plugs. A quick self-locking feature provides for snap-in contacts, holds the contacts firmly in position, and requires manual release by means of levers. Identification markers are clearly visible when the lever is in the locked position.

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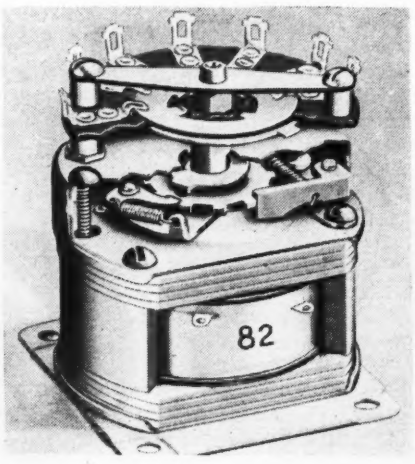
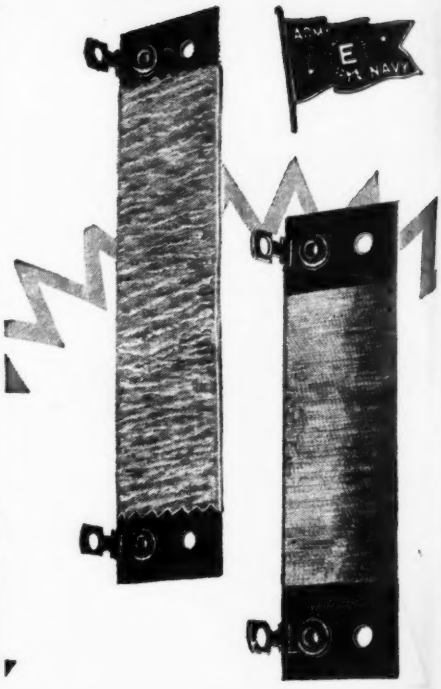
Rotary Relay

THE TYPE 82 ROTARY RELAY stepping unit is a compact twelve-position driving mechanism which operates a shaft extension through 360 deg





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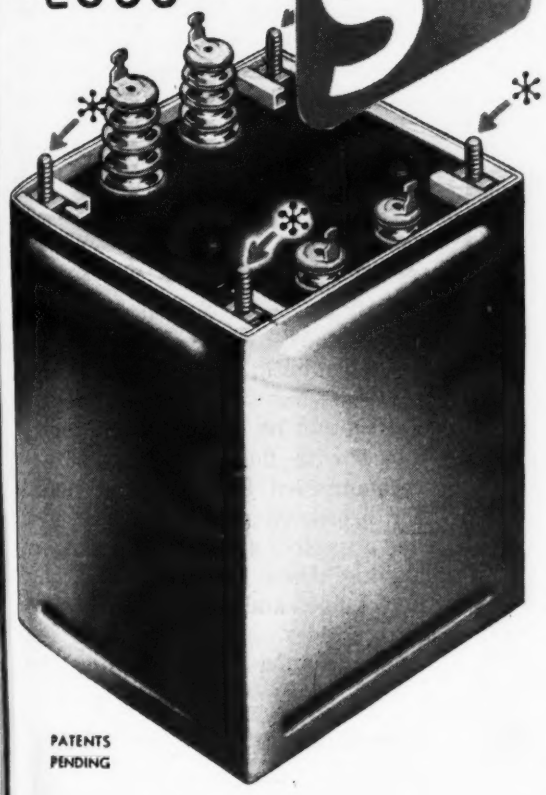

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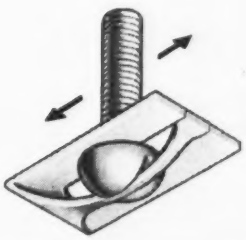
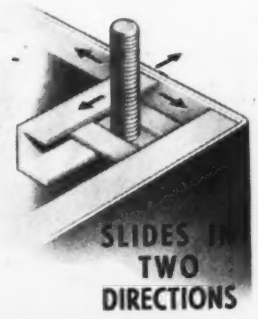


Detail shows the simple arrangement that prevents stud from turning while it permits centering in two directions. Clip is stamped from heavy gauge, cadmium plated steel.



In position for mounting, the stud can be moved (NOT BENT) in FOUR directions to align with poorly spaced holes. Strains applied to stud through excessive tightening are absorbed by mount.

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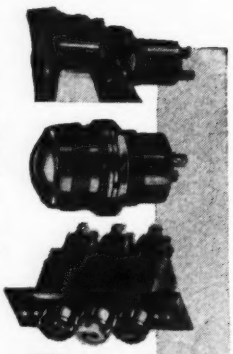

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in twelve progressive steps. The unit illustrated provides a twelve-position selector switch, which indexes one position for each momentary current impulse and will drive up to three wafer switches, or any other load not in excess of twelve ounce-inches torque. It can be made to operate clockwise or counter clockwise. Actuators can be furnished either as direct drives (indexing the load with the current impulse), or as spring drives (indexing the load following the current impulse). Current required to operate the relay depends upon the torque required for a particular application.

Price Brothers Co., Frederick, Md.

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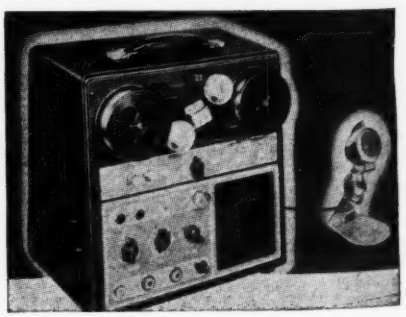
BROADCAST STATIONS can now purchase Model 51 portable multi-purpose magnetic wire recorders for the first time since the war began. Speech can be recorded and reproduced with fidelity, but it is not recommended for recording music for broadcast purposes. The unit has a number of improvements, including a new recording head, new belt drive, and new level-winding wire guides. The steel case has been changed to aluminum, decreasing the over-all weight from 47 to 35 lb. The unit operates directly from any 105-120-v a-c line. It is supplied with a high-fidelity microphone, microphone stand and cable, power cord, one 12,000-ft spool of recording wire and one empty spool. Recordings may be kept as a permanent record or be erased magnetically and the wire used again for other recordings. Recordings or play-back are accomplished at the flip of a switch.



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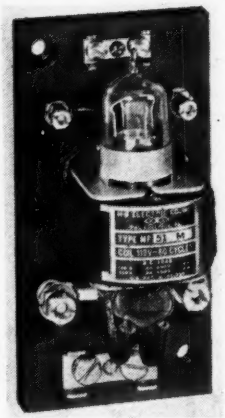

capacities as high as 30 amp. The mercury-to-mercury hermetically-sealed contacts are positive, chatterless, noiseless, with no exposed arc. Type MP-51-M relay is illustrated.

H-B Electric Co., 6109 North 21st St., Philadelphia 38, Pa.

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Connection—Either series or parallel.

Sensitivity—18 dynes 1 sq. cm. for 10 microwatt input per receiver.

Construction—Rugged and stable, using only finest materials, precisely machined—no diaphragm spacing washers in Telex Twinset receivers.

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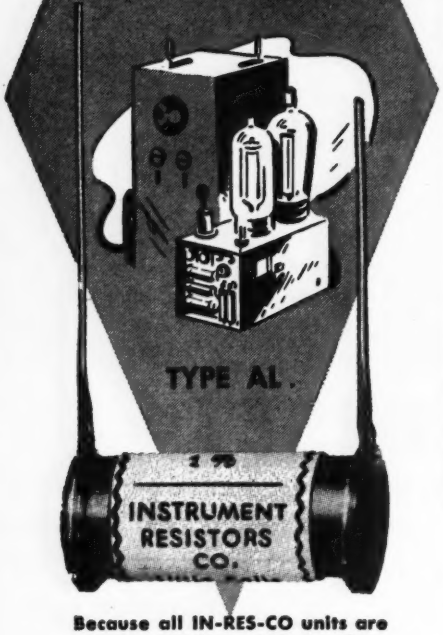

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Literature

H-F Iron Cores. These cores are designated as Crolite Magicore high-frequency cores and are described in a catalog by that name. The catalog contains thirty-three pages of descriptive matter and graphs, and gives all the information one needs to know about these powered iron cores. Henry L. Crowley & Co., Inc., West Orange, N. J.

Facsimile Communication. Elements of Facsimile Communication is the title of an 18-page book aimed at persons who are just becoming acquainted with facsimile communication. The booklet contains diagrams of the various parts of facsimile equipment and describes their individual functions. Times Telephoto Equipment Inc., 229 West 43rd St., New York 18, N. Y.

Electrical Insulating Materials. Engineering Bulletin No. ED-44 contains testing data, properties, forms, graphs, fabrication, design and uses of electrical insulating materials available from Continental-Diamond Fibre Co., Newark, Del.

Raytheon Tubes. A 44-page catalog entitled Radio Tube Data and Substitution Chart incorporates the latest technical information not previously available on this manufacturer's radio tubes. Electrical characteristics with outline drawings and diagrams of radio receiving tube types, as well as information on hearing aid tubes, special purpose tubes and radio panel lamps are included. Over 1600 substitutions are listed. Radio Receiving Tube Div., Raytheon Mfg. Co., Chapel St., Newton 58, Mass.

RCA Radio History. Twenty-five Years of Radio Progress With RCA is the title of an 88-page book published as a token of the 25th anniversary of Radio Corporation of America. It is the history of quarter of a century in radio and electronics. Department of Information, Radio Corporation of America, 30 Rockefeller Plaza, New York 20, N. Y.

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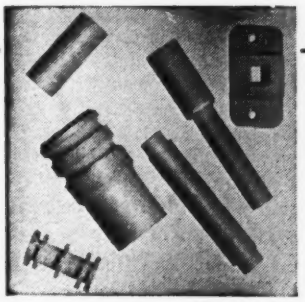

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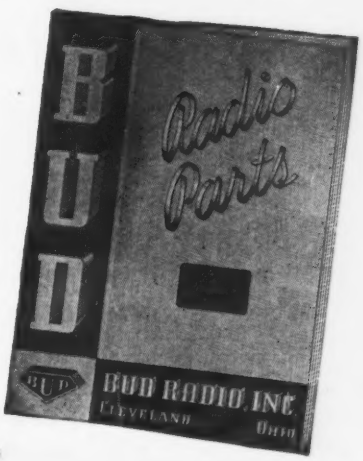

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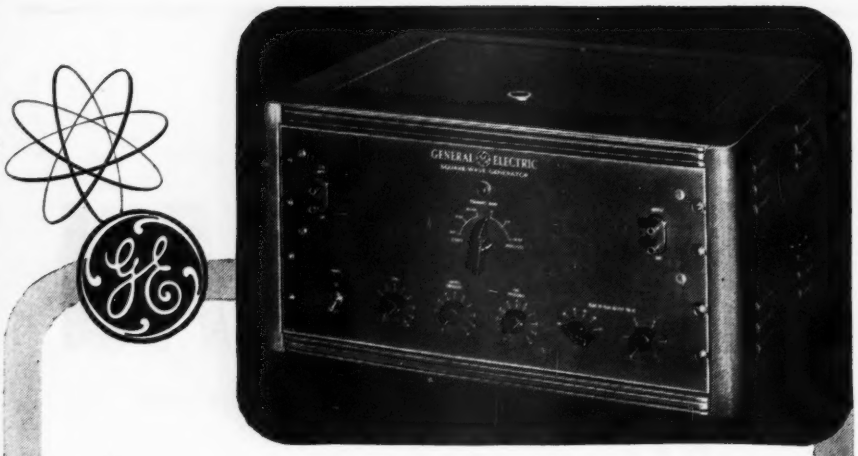

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Fiberglas Insulating Materials. Catalog No. EL44-7 entitled Electrical Insulation Materials illustrates and describes the many types of insulation available and gives characteristics. It is a 24-page booklet. Owens-Corning Fiberglas Corp., **Toledo 1, Ohio.**

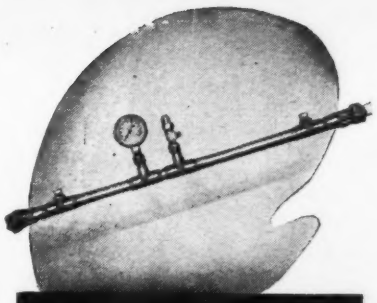
Cable Assemblies. For manufacturers of aircraft, marine, radio and electrical equipment and parts there is available a 28-page catalog which describes and illustrates engineered cable assemblies available from Whitaker Cable Corp., North Kansas City 16, Mo.

Micro Switch Catalog. This new handbook consists of 100 pages, is handsomely illustrated and describes over 500 heavy-duty type micro switches and auxiliary devices for electrical control in aircraft, marine, railway, automotive and heavy machinery. It is designated as Handbook Catalog No. 71, and is cross indexed for easy reference. Micro Switch Division, Freeport, Ill.

AN Insert Chart. This chart contains complete and practical data of molded AN insert arrangements for electrical connectors. Standard inserts from one contact to one hundred contacts are shown in full size. Inclosed with the chart is data about An and Amphenol 97 shell types and styles. American Phenolic Corp., 1830 South 54th Ave., Chicago 50, Ill.

Electronic Precision Instruments. Background data is included in a 12-page booklet which illustrates and describes such units as housing for radio antennas, central-office traffic control, cathode-ray radio direction finder, under-water radio sound equipment, capacity goniometer, wave meter, 10-channel h-f receiver, and precision mechanical devices. Airplane & Marine Instruments, Inc., 52 William St., New York, N. Y. and Clearfield, Pa.

Radio Components. Hard-to-find parts and electronic and radio components are listed in a new Special Supplement No. 97 available from Concord Radio Corp. (formerly Lafayette Radio Corp), 901 W. Jackson Blvd., Chicago 7, Ill.



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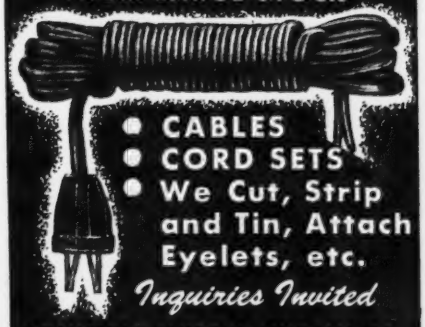

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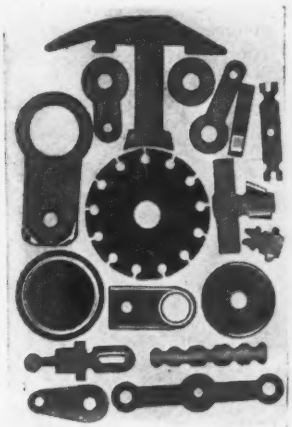

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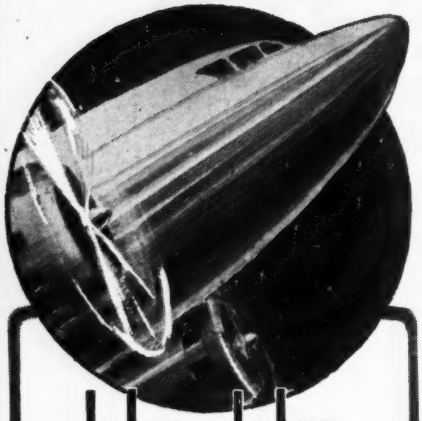

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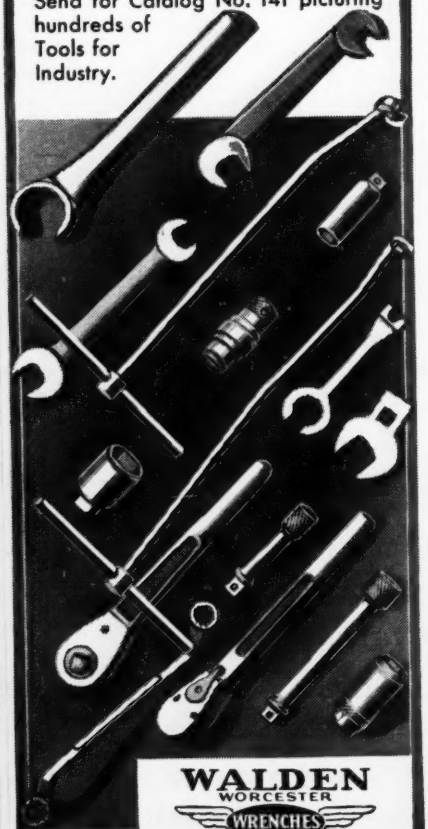

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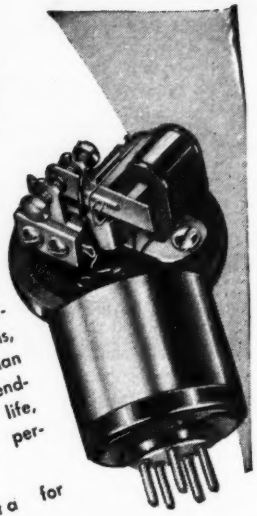

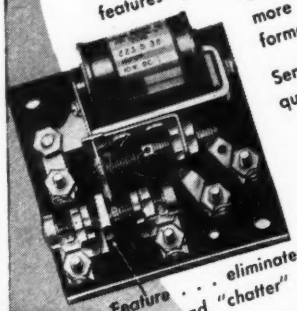

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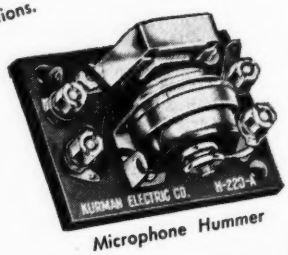

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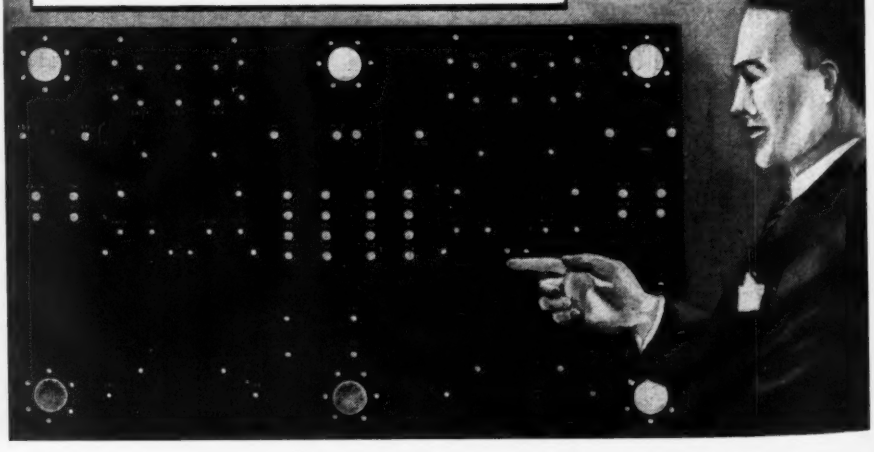

Vibration Insulators. Duflex, Series No. 1022, vibration insulators are described and illustrated in an 8-page catalog. Harris Products Co., Cleveland 4, Ohio.

Test Set Assemblies. Manufacturers of electrical equipment (wire, cable, instruments, motors, appliances and insulating materials) who need to measure, accurately and easily, the insulation resistance of their products will be interested in an 8-page catalog entitled To Measure Insulation Resistance—L&N Test Set Assemblies. Two assemblies (one for routine plant use and the other for laboratory measurements) are described. This catalog (No. EO54-460(1) is available from Leeds & Northrup Co., 4934 Stenton Ave., Philadelphia 44, Pa.

Directory Listing. A new 1944-45 Directory listing 440 member plastics concerns in the United States and Canada is available at $2.50 from the Society of the Plastics Industry, Inc., 295 Madison Ave., New York 17, N. Y. More than 700 different plastics products are alphabetically listed together with the manufacturers of each. Also contained is a section on who's who in the plastics industry. The book contains 247 pages.

Post-War Personnel Problems. A book entitled Personnel Problems of the Postwar Transition Period was written by Charles A. Myers of the Industrial Relations Section of MIT for the Committee for Economic Development. The study was based on the experience of 32 manufacturing and non-manufacturing companies. The purpose of the book is to make known what a few outstanding companies are already doing in the belief that the scope of experience covered in the book will be valuable to other companies facing these questions. It is an interesting book.

Varnished Tubing Standards. The second edition of standards for varnished tubing and saturated sleeving used for electrical insulation is available. Standards contained in the 8-page booklet are standards adopted by the Varnished Tubing Association, Inc., 420 Lexington Ave., New York 17, N. Y.

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Laboratory Standards

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CARRIER FREQUENCY: 300 to 1000 megacycles.

OUTPUT VOLTAGE: 0.1 to 100,000 microvolts.

OUTPUT IMPEDANCE: 50 ohms.

MODULATION: SINEWAVE: 0—30%, 400, 1000 or 2500 cycles. PULSE: Repetition—60 to 100,000 cycles. Width—1 to 50 microseconds. Delay—0 to 50 microseconds. Sync. input—amplifier and control. Sync. output—either polarity.

DIMENSIONS: Width 26", Height 12", Depth 10".

WEIGHT: 125 pounds including external line voltage regulator.

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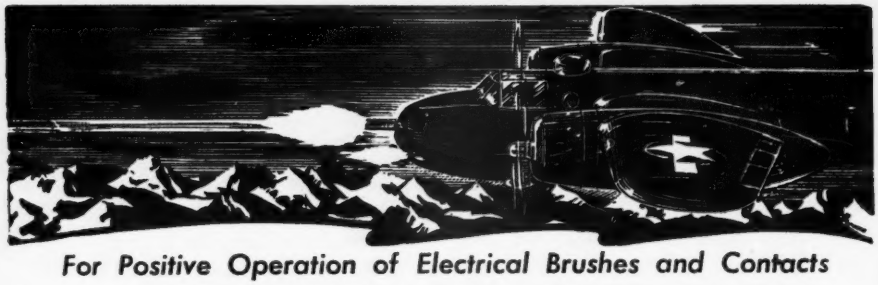

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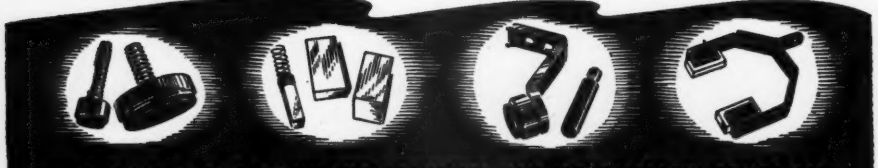

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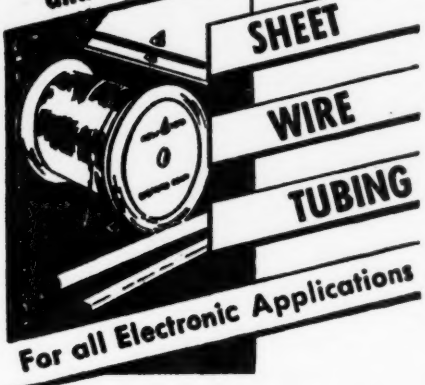

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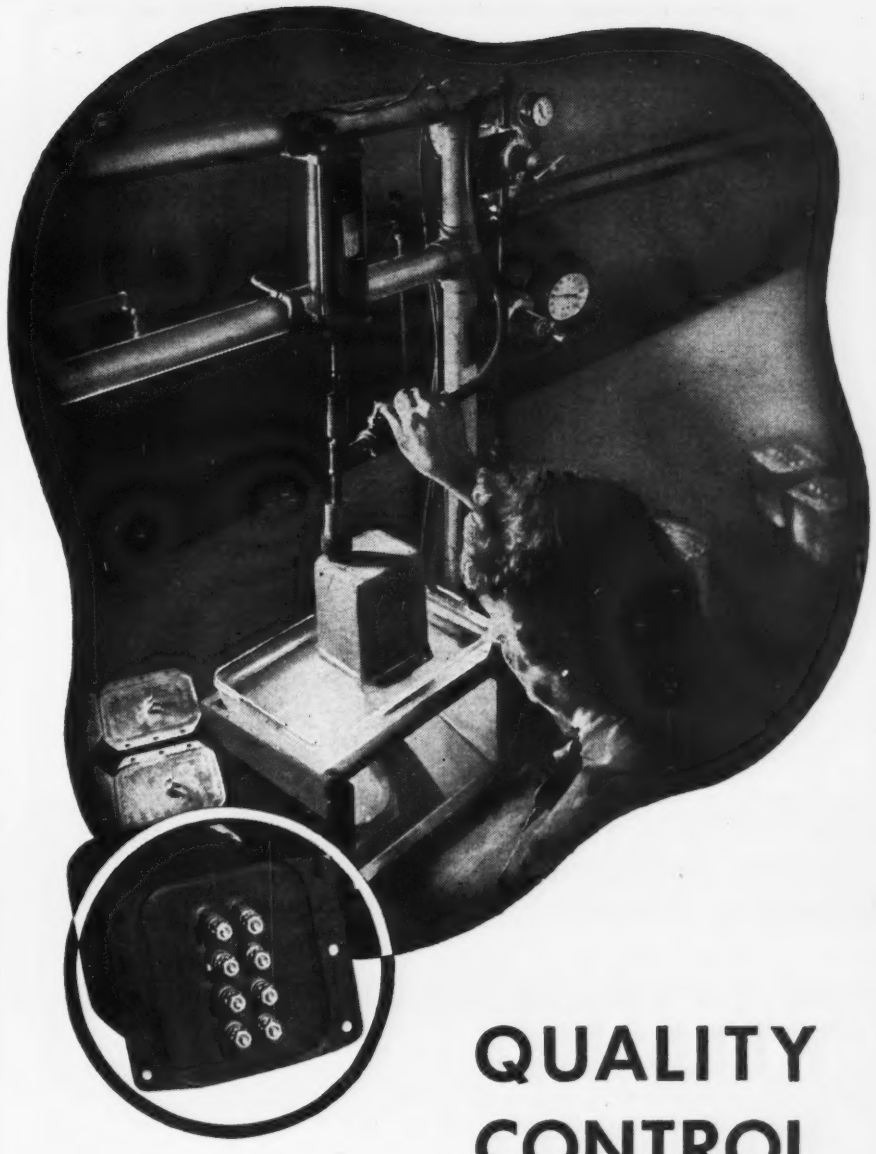
Production Inspection Equipment. Bulletin No. 3544 is a 16-page booklet of illustrations and descriptive matter on a new inspection cabinet for continuous x-ray examinations of parts on a production schedule. Picker X-Ray Corp., 300 Fourth Ave., New York, N. Y.

Electronics Book. Can Electronics Improve Your Products is the title of a 32-page, illustrated booklet designed to provide practical information regarding this manufacturer's facilities and capacity for the production of electronic sub-assemblies and parts. Several pages are devoted to a non-technical discussion on what electronics is and what it does. Operadio Mfg. Co., St. Charles, Ill.

X-Ray Diffraction Apparatus. Bulletin No. 1XD11-44-10 describes and illustrates x-ray diffraction techniques and applications. Diagrams, typical diffraction films, and several tabulations are given to show how Norelco equipment is used for identification, research and production. North American Philips Co., Inc., 100 East 42nd St., New York 17, N. Y.

Capacitor Catalog. This catalog provides practical working data on ceramic capacitors. It contains 81 standard rating ceramic capacitor samples and some working samples. Plant illustrations, which show the manufacturing processes and testing methods including the application of solid silver for condenser plates, are included. An ASA color code makes the catalog useful as a reference source. Electrical Reactance Corp., Franklinville, N. Y.

Bendix Radio Bulletins. Units such as 2500-w ground station equipment (Model TG-14), u-h-f signal generator, video signal generator, expressor amplifier, power supplies and marker receiver are all described in separate pieces of literature available from Bendix Radio, Div. of Bendix Aviation Corp., Baltimore 4, Md. The literature on ground station equipment is a 20-page bound catalog which contains descriptive matter and illustration on the TG-14 series.



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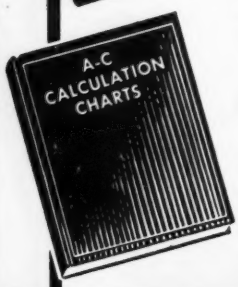

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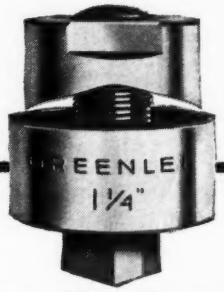

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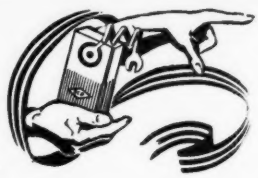

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Communications History. Tom Tom to Electron is the title of an interesting 42-page catalog which is designed to be a story of communications. With this thought in mind this manufacturer has made an attempt to chronologically portray in picture and fact the history of communications. The booklet contains background data as well as descriptions of the products of Link Radio Corp., 125 West 17th St., New York 11, N. Y.

Electrically - Operated Switches. Circular No. 600 describes such electrically-operated switches as automatic transfer switches, remote control switches, and contactors and relays. Automatic Switch Co., 41 East 11th St., New York, N. Y.

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Unimpaired Fluxing Power

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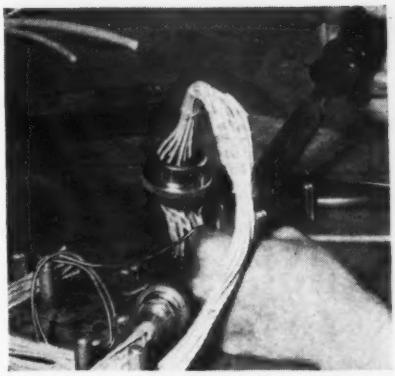

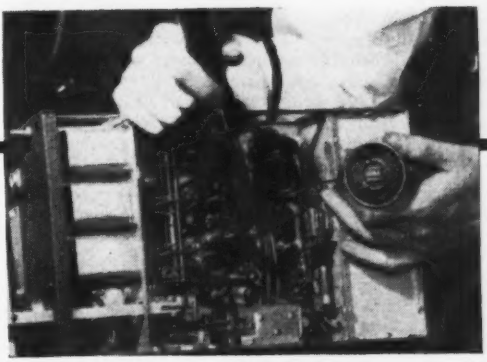

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NORCO

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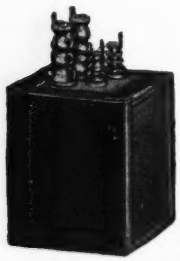

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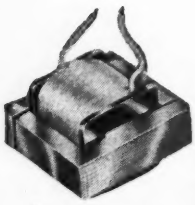
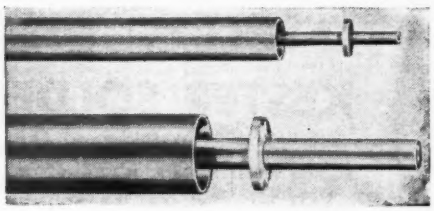


TRANSFORMERS

SPECIAL COILS



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Transformers. Bulletin No. 431 contains photographs and illustrations, diagrams, full construction details, and prices on the complete line of transformers, windings and reactors available from Peerless Electrical Products Co., 6920 McKinley Ave., Los Angeles 1, Calif.

Theater Television Handbook. A comprehensive handbook on the what, how and why of theater television is profusely illustrated. It is primarily devoted to technical discussion of the reception and large-screen projection of television programs. Several chapters deal with such non-technical subjects as television commercial possibilities, the handling of programs, and audience response. The book, aimed primarily at projectionists, is called Theatre Television Handbook for Projectionists. RCA Service Co., Inc., Camden, N. J.

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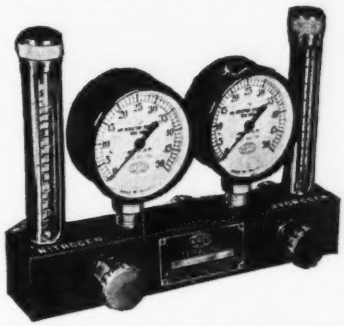

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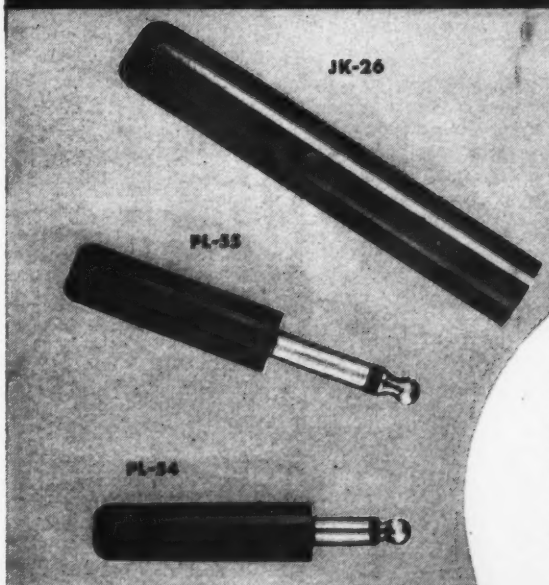

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Alignment Charts, Construction and Use

By MAURICE KRAITCHIK, *Professor of Mathematics, New School for Social Research, New York. D. Van Nostrand Co., Inc., New York,* 1944, *94 pages,* $2.50.

GENERAL PRINCIPLES of choice and graduation of scales and methods of representation for nomographs are illustrated by conversion and alignment charts of up to five variables. Although none of the charts deal specifically with electronics, the method of their construction is applicable to nomographs in electronic and allied fields. The presentation assumes a working knowledge of geometry and algebra.—F.R.

• • •

Marine Radio Manual

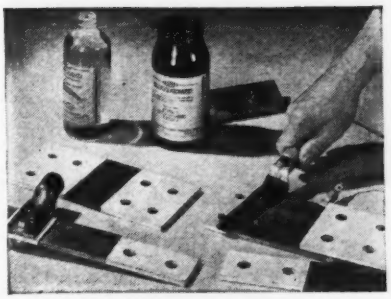
EDITED BY M. H. STRICHARTZ. *Cornell Maritime Press, 241 W. 23rd St., New York 11, N. Y., 518 pages, $4.00.*

IN NOT MANY INSTANCES can the "tricks of a trade" be bundled into a single volume that can be used as a bible by both learners and masters, but Mr. Strichartz is one person who has accomplished this admirably in "Marine Radio Manual." The book was written—assembled would be a better word because many sources were used—to serve as a guide for students who are learning to become radio officers on ships and as a refresher and manual for experienced operators.

That the purpose of the editor has been achieved is clearly evidenced by the comments of the Hon. Schuyler Otis Bland, chairman, Committee on Merchant Marine and Fisheries of the House of Representatives, in the foreword. He says:

"This manual deals with all phases of radio at sea and has been prepared as a textbook for schools training young men for radio service. It gathers between the covers of one volume all of the data needed for performing the duties of the radio operator on merchant ships.

"It has the tang of the sea on every page, for the manuscript was written in waters both safe and



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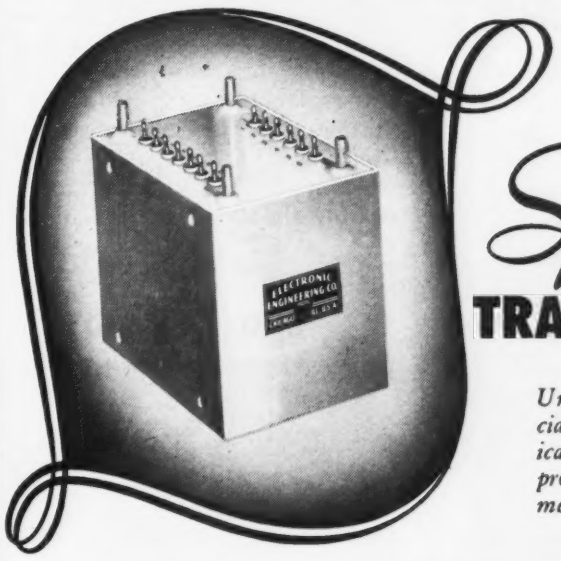

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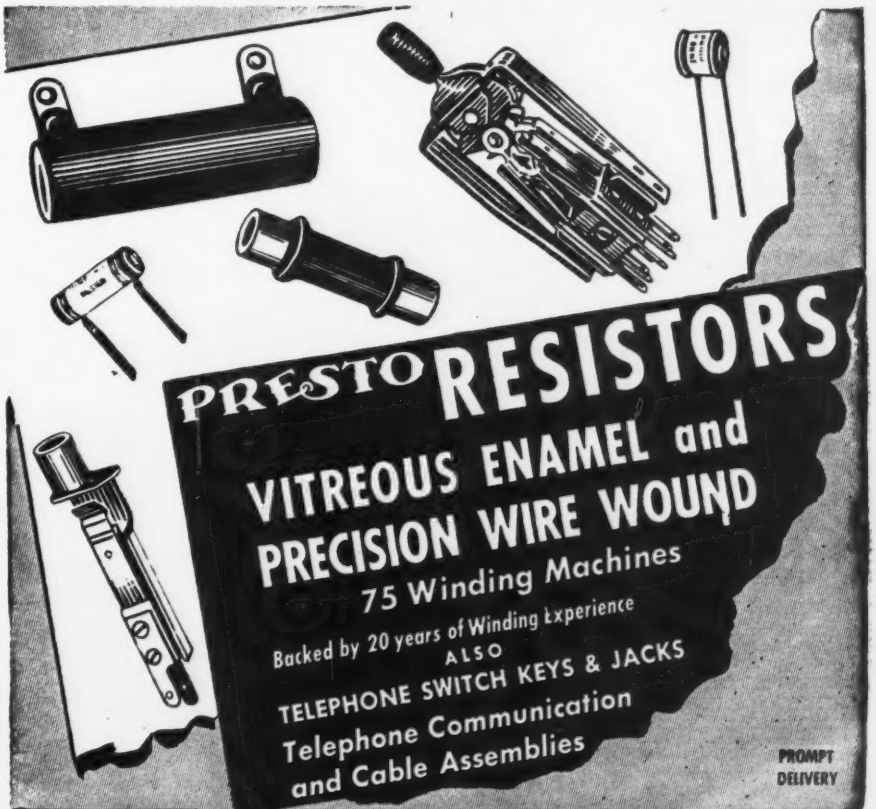

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dangerous and on ships carrying cargo as different as coal and blockbusters. The editor's main fear during those dangerous days was lest he should lose his manuscript and small library. So precious were they, that when his ship ran on the rocks, after the editor had sent the SOS signal his chief concern was the preservation of the manuscript. One of his comrades found him consuming valuable time wrapping the manuscript and material in his life jacket and immediately reached the conclusion that he had gone crazy."

A radio officer's duties on a ship cover not only operation and maintenance of the equipment but actual business transactions and bookkeeping connected with sending and receiving messages. In this work he is governed by a mass of laws, rules and regulations laid down by several government agencies, the steamship company that employs him, the radio service company that owns and installs the equipment and the traditions of the sea and of his particular branch of the service. To explain all of the duties Mr. Strichartz begins with a short sketch of maritime radio history. He then delves right into all phases of the work by taking up each one in a separate chapter. Headings of these chapters are self-explanatory—the ship's radio station, the maritime radio operator, laws affecting radio officers, work in port, work at sea, radio operating, the "business" of radio tele-

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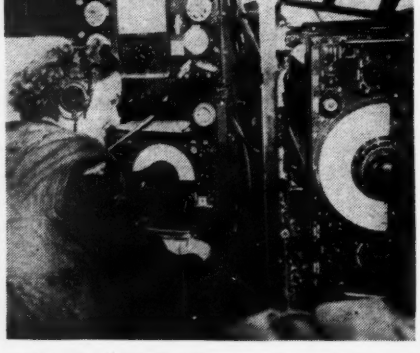

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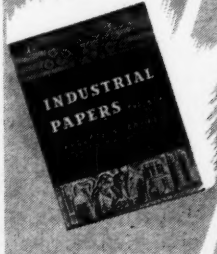

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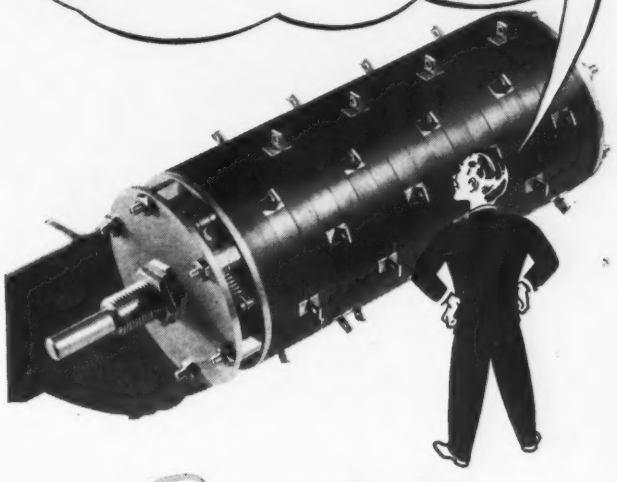

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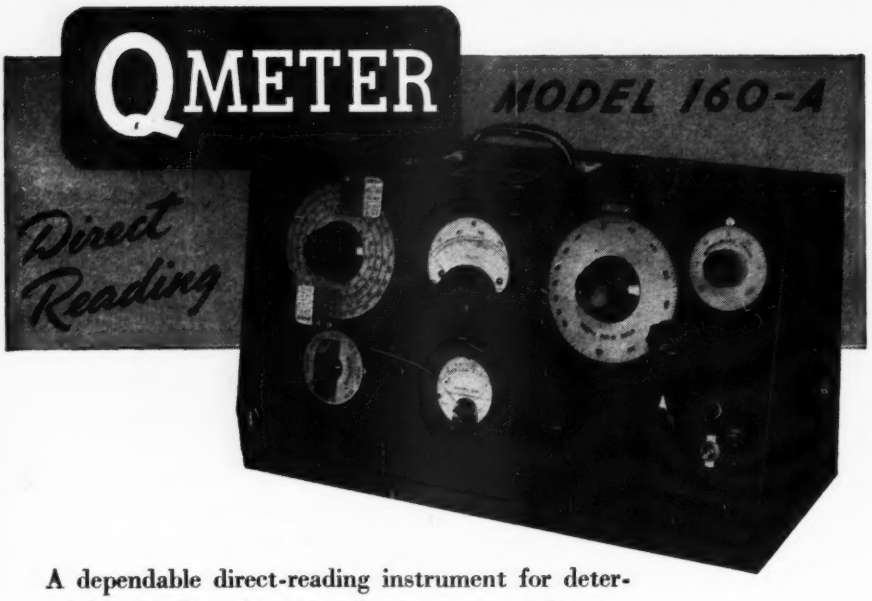

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One of the commendable points about this book is that the author has not gone into detailed "why's and wherefore's." Thus, it is not loaded down with lengthy explanations, which makes it interesting reading whether or not one intends to become a maritime radioman. It is crammed with details, however, about duties and equipment and therein lies its greatest general interest to the electronics field. As one browses over the descriptions of the equipment and what functions it performs there arises a feeling of pride and, possibly, pleasant surprise at what has been accomplished by electronic engineers.

The highest praise a layman could give this book is contained in the statement made by Representative Bland in the foreword when he says, "Personally, it would have been one of my greatest pleasures to have had such a volume on April 18, 1921 when I began my service on the Committee on Merchant Marine and Fisheries."—K.S.P.

• • •

Meet the Electron

By DAVID GRIMES, *Pitman Publishing Corp., New York 19, N. Y., 1944, 120 pages, $2.00.*

THIS BOOK is a brief, lucid exposition of the nature and characteristics of the electron and the many technical developments which are based upon modern knowledge of its behavior. The stories in it have been told and retold by the author over a period of twenty years to many thousands of fascinated listeners in auditoriums, schools and lecture halls, and preparation of the manuscript for this book had been almost completed at the time of his fatal airplane crash in Ireland.

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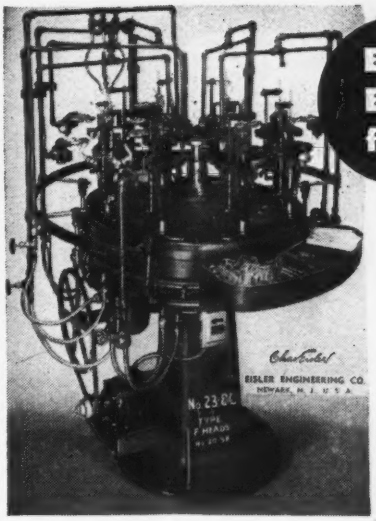

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their scientific explanations are reviewed in story fashion with unusual simplicity and clarity. Essential facts are narrated so sketchily yet interestingly that readers with a little more than an elementary knowledge of electronics are likely to be disappointed because more details are not included. But to readers who are not students of science this book should make clear any mystery which may surround electronics and its applications.

An overall pattern is depicted which portrays the universal existence of electrons in nature, their actions in conductors carrying current, and their relation to magnetism. On this groundwork an explanation follows of how electronic activity is put to work in vacuum tubes and in radio reception and transmission systems. To complete the picture, related subjects are included such as sun spots, electron chemistry, electron sources, wave bands, inventions of Alexander Graham Bell, music on light waves, and television.

Pen and ink sketches by J. Riegel, Jr., are a notable feature of the book.—J.K.

• • •

Seeing the Invisible

By GESSNER G. HAWLEY, *Alfred A. Knopf, Inc., New York, 1945, 200 p., $2.50.*

THE ELECTRON MICROSCOPE, how it works, how it was developed, and its possibilities in research in many fields are described in language for the layman. The author admits that he may not secure unqualified approval of experts because of the lack of details of construction and operation. Even a student would need some of these, but he could not help but become a more interested student for having been made familiar with the vastly widened possibilities open to him in research.

The nine chapters in the book begin with a word picture background telling of "the search for the small", comparing the principles of the optical and electron microscopes. It is shown that light, on which the former depends, is too coarse a tool to distinguish particles less than 0.000008 in. in any dimension. The electron microscope distinguishes particles one hundredth that size. Particles are not only

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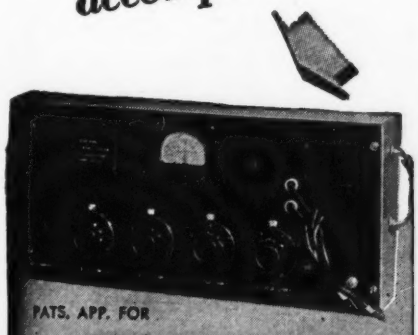

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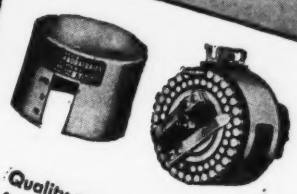

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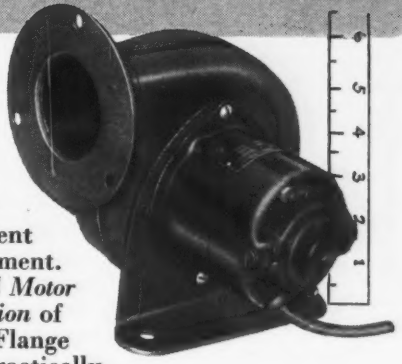

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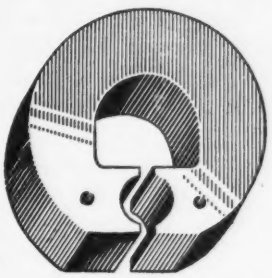

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The "why" of invisibility is explained in Chapter 2 by the length of visible light waves which, ranging from 0.000025 to 0.00005 in., are much longer than the particles that they have been called upon to make visible. How electrons are controlled to produce larger and better images is described in Chapter 3.

Two major limitations of the electron microscope, which are pointed out in Chapter 4, are that specimens to be examined must be subjected to high vacuum and its excessive drying action as well as to the heat produced by the electron stream. These are particularly serious in studying biological organisms. Examination of dense materials such as metals requires an indirect procedure, recently developed.

The history of the electron microscope is also an interesting story as told in Chapter 5. Some of the things already accomplished with the electron microscope are described in Chapter 6, the studies of carbon black as related to rubber and synthetic rubber being particularly interesting. Further accomplishments and reports on what is being attempted with the microscope are dealt with in the next chapter.

The possibilities in medical research, discussed in Chapter 8, are shown to be great in spite of previously mentioned limitations of the instrument. Pictures have been made of numerous bacteria, bacteriophages, blood corpuscles, the anatomy of insects, and related subjects.

"What lies beyond?" is a brief concluding chapter. It probes the further development of the instrument and technique of using it, perhaps for "seeing" even smaller particles such as molecules and even atoms.

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Semper Fidelis!

Dear Mr. Henney:

MAY I BE permitted to convey my hearty and unqualified concurrence with the views expressed in "Cross Talk" in the December issue of ELECTRONICS. . .

It would be a gross understatement to say that I have been disturbed by some of the literature recently released purporting to show preference for degraded reproduction and the quasi theory to substantiate the findings.

You succinctly call attention to the fallacies and weak points in current studio practices—which in themselves defeat dispassionate findings in "high fidelity" tests.

I feel that you are personally acquainted with our efforts to honestly find the answers to faithful reproduction in experiments which go back many years—with no axe to grind except to learn the truth—and it is a comforting reassurance to find a friend at court with the influence obviously enjoyed by ELECTRONICS.

I. B. ROBINSON
Technical Director
The Yankee Network
Boston, Mass.

At the risk of being called idealistic, ELECTRONICS will continue to be against hamstringing high fidelity at the start and then waiting ten years to wish there had been more vision.—(Ed.)

• • •

Mathematics by the Ten Millions

Dear Sirs:

MY PAPER, "Secondary Electron Radiation," (in the September issue) seems to have attracted a certain amount of attention in this country, because three misprints in it have been pointed out to me. I thought perhaps you might like to put a correction in the next issue of ELEC-

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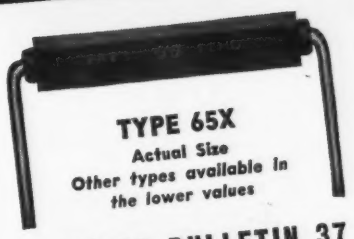

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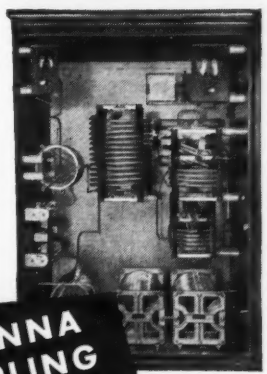

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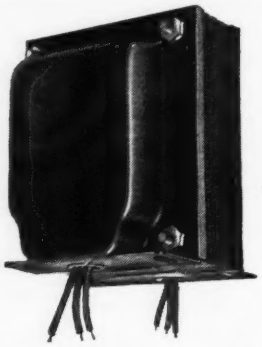

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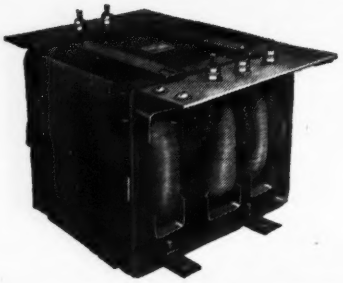

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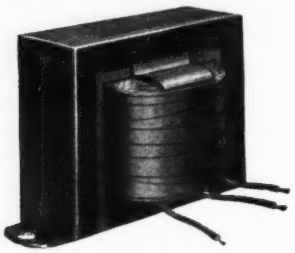

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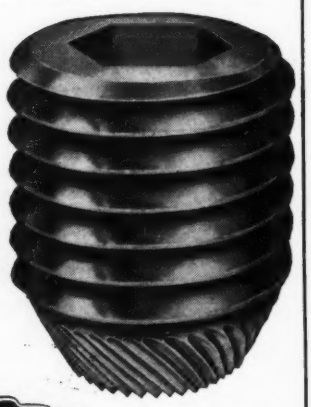

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TRONICS. The misprints are as follows:

(1) In the first column of the text on p. 100, the formula for v should read:

$$v = 5.95 \times 10^{7} \sqrt{V}$$

(2) Figure 14: The numerals along the abcissa should commence with 1 and not with 0, since this is a logarithmic scale of frequency.

(3) In the Bibliography, item 82, my name "Harris" should, of course, be spelled

J. H. OWEN HARRIES
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• • •

Repairmen and Hams

I AM IN one-hundred-percent agreement with Mr. B. P. Schroeder as to the disposition of surplus materials.

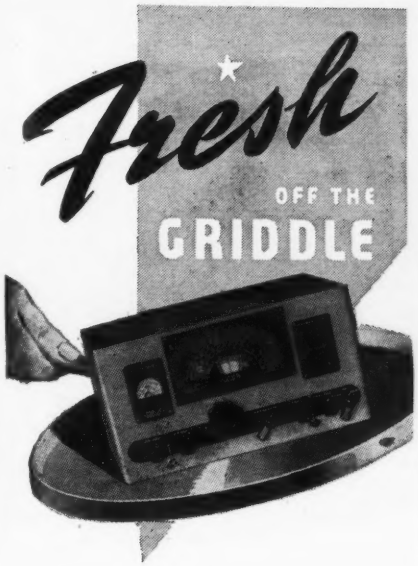
It would be very easy for the War Dept. to limit the sale of such materials so that large buyers could not grab all available surplus, store it a few years, then black market it to buyers.

Any gear in need of repairs usually can be serviced by the individual who uses it, sometimes with the help of the manufacturer regarding parts of special nature and diagrams.

I feel this can be done not only with electronic testing equipment, but also with surplus tubes, transformers, etc.

There are many servicemen of electronic equipment who, as Mr. Schroeder suggests, cannot afford refined equipment and possibly never will be able to. Take for example the serviceman who aligns a radio receiver with signal generator and output meter. His customers would certainly be more willing to recommend him after hearing the better quality and performance from an alignment job with a frequency-modulated oscillator and 'scope—which most servicemen cannot afford, and others who can afford don't know how to use.

This obviously puts a different light on the subject—the less wealthy serviceman who has knowledge but not money would be well able to pit his knowledge against the other fellow's money since he will be able to get the necessary



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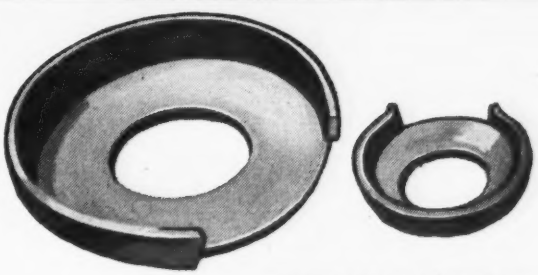

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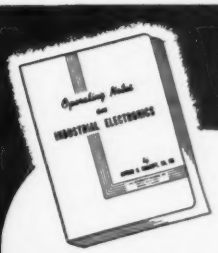

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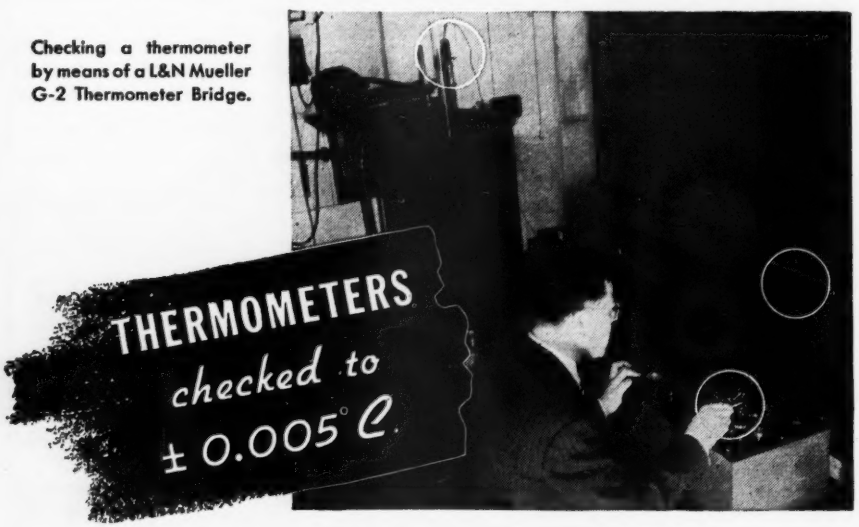

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equipment, and knows how to use it.

As for the manufacturer—the surplus material would eventually enable the above-mentioned serviceman to get new products, and the manufacturer would gain in the long run.

Of course we can also mention the electronic home inventor and his experiments, the radio amateur—usually making a living at some other endeavor—and so forth. All these persons would be able to get equipment to enable them to perform their experiments with more accuracy, guess work would be minimized, and their help to the technical world would be improved.

Codeless Hams?

While many organizations such as the RTPB, ARRL, etc. are interested in frequency allocation and other technical matters, it seems to me that they might give some thought to the idea of refining the laws governing radio amateur communication. For example, I can see no logical reason why an amateur must know the Morse code in order to operate a station.

This seems absurd because there are many persons who would like to put stations on the air for purely scientific purposes (Kennelly-Heaviside measurements, and the like). These scientific-minded persons (some of them college professors) find their time fully taken up with responsibilities which limit and usually crowd out the time necessary to learn code in operable manner.

Almost anyone can recognize an SOS and knows, if he cannot respond, at least to get out the way and help by a telephone call to the Coast Guard.

It seems more logical that the technical examinations and law be given priority and amateur licensees be split into the radio telephone and radio telegraph groups as the commercial licensees are.

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TWO IMPORTANT JOBS ..... Cover
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600 VDC	Single Units	.05, 0.1, .25	Mfd.
	Dual Units	.05, 0.1,	"
	Triple Units	.05, 0.1,	"
1,000 VDC	Single Units	.05, 0.1	Mfd.
	Dual Units	.05, 0.1	"
	Triple Units	.05	"

STANDARD CAPACITANCE TOLERANCE plus or minus 20.%**

TEST VOLTAGE . . . . . twice DC rating

GROUND TEST . . . . . 2,500 Volts DC

OPERATING TEMPERATURE . . . 55°F. to 185°F.

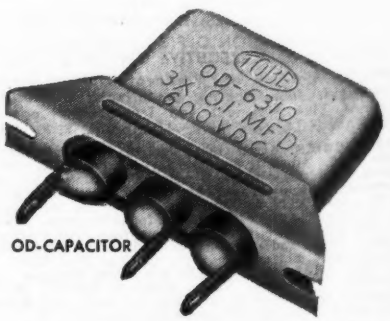
SHUNT RESISTANCE:
.05 to 0.1 Mfd.—20,000 Megohms
.25 Mfd. —12,000 Megohms

POWER FACTOR . . 1,000 cycles—.002 to .005

CONTAINER SIZE:
Width 9/16", length 1-11/16", height 1-17/32"

MOUNTING HOLE CENTERS . . . . . 2-1/8"

Illustration shows capacitor with bottom terminals. Capacitors also available with top terminals.



OD-CAPACITOR

*Data sheets showing complete code number for units having a specific capacitance value and voltage ratings available on request. **Other tolerances available.

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